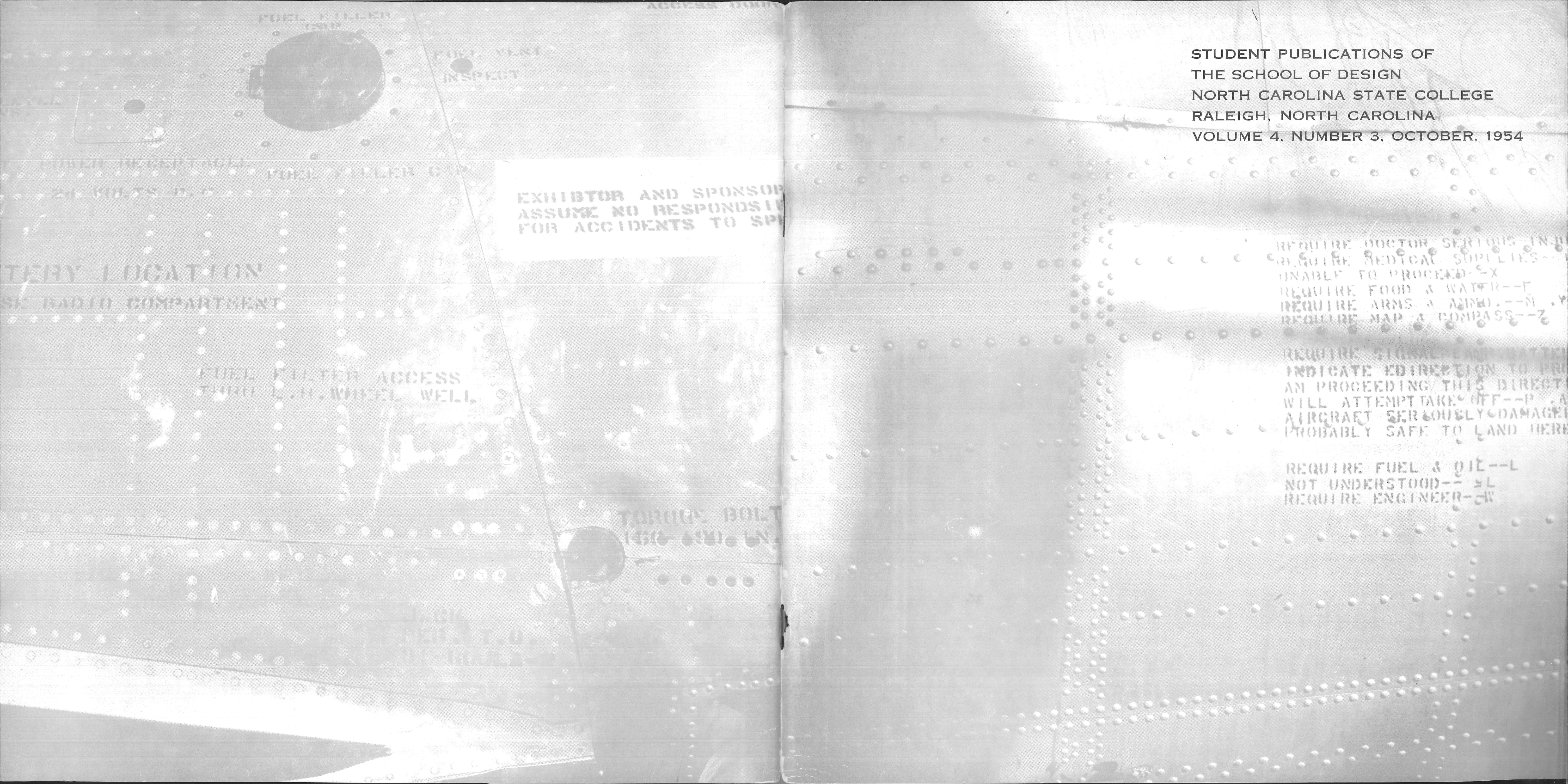

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We will live through a time of immense change; as architects we are bound to follow and promote this change wherever it is for and not against life. In architecture technical change is long overdue. We have only to open our eyes to what is being built in other fields—ships, aeroplanes, wireless sets, motor cars—to see our own ludicrous situation and take hope. Socially we stand in a desert that cries out for new growth—that needs new social structures to give shape and direction to the movement of our lives. This need goes deep; but we can—we must—evolve ways of working towards it. Collective ways, because our problem is the painter's, the factory worker's, the physicist's, the anthropologist's. With our different ways of working directed together towards life, we can begin again. Fifty years ago men began to fly. With the same excitement and patience we can begin to live and to build.

PLAN Magazine.

VOLUME 4 NUMBER 3 OCTOBER 1954

STUDENT PUBLICATIONS OF THE SCHOOL OF DESIGN

FROM PLAN MAGAZINE

NEW FEELINGS NEW TECHNIQUES

This article originally appeared in PLAN, the Journal of the Architectural Students' Association, School of Architecture A. A., London, England, and is reprinted with their permission.

"An uninterrupted navigable ocean, that comes to the threshold of every man's door, ought not to be neglected as a source of human gratification and advantage."

For thousands of years men had tried to fly. Time after time madmen battered the intangible air with feverish combinations of wings, oars and paddle-wheels, but it would not be conquered. One by one they fell to death and became heroic legends. Until, at the beginning of the nineteenth century, magic began to yield to the certainty of science. The urge to conquer became the need to understand, and men began to see in the bird's equipoise in moving air the idea, rather than the form, of human flight.

Later in the century science and skill combined in men like Otto Lilienthal who studied the soaring flight of the albatross and built himself a rigid glider based on its lifting form. In long years of discovery he gradually refined the structure of his wing, and came to understand the nature of the supporting air through which he sailed.

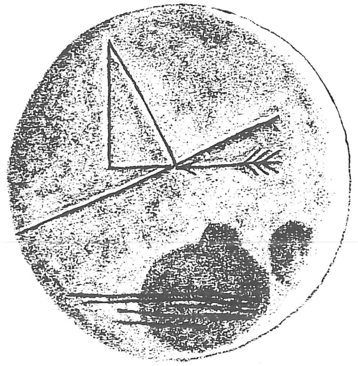
He was learning to fly.

The dream of centuries began to come true.

Courtesy of the Director of the Science Museum, South Kensington, England

1799

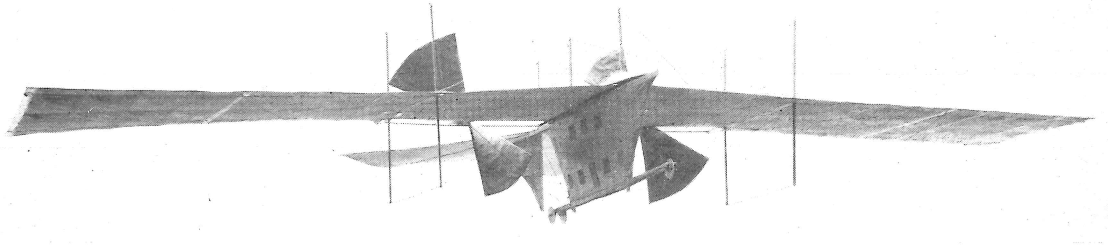
George Caley made a mathematical analysis of the problem of flight and defined it thus: *"To make a surface support a given weight by the application of power to the resistance of the air"*. He is the pioneer of the aeroplane. He engraved this coin showing the triangle of forces on a bird's wing in gliding flight, and introducing for the first time the ideas of lift and drag.



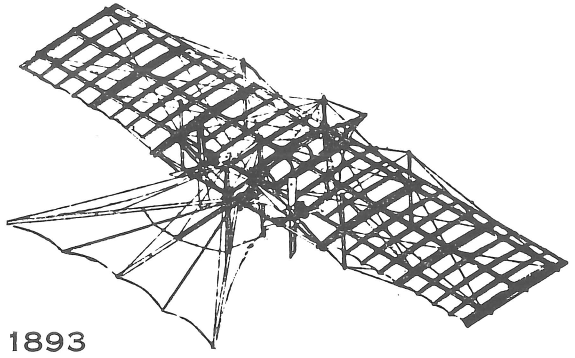
He said: *"A common paper kite would skim for twenty or thirty yards supporting its own weight; it gave the idea that a larger instrument would be a better and safer conveyance down the Alps than ever the sure-footed mule, let him meditate his track ever so intensely."*

Henson and Stringfellow founded the *"Aerial Steam Transit Company"* which was based on *"Certain Improvements in Locomotive Apparatus and Machinery for Conveying Letters, Goods and Passengers from Place to Place through the Air, etc."* Their scaled-down prototypes, though hedged around with patents, refused to leave the ground.

1843



Courtesy of the Director of the Science Museum, South Kensington, England

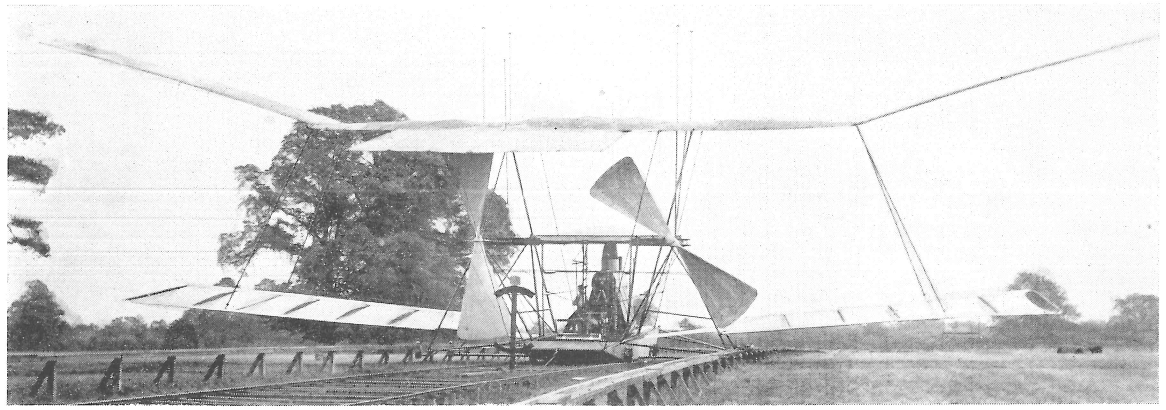


Stringfellow describes one of their tests: *"There stood our aerial protegee in all her purity—too delicate, too fragile, too beautiful for this rough world. I soon found, before I had time to introduce the spark, a drooping in the wings, a flagging in all the parts. In less than ten minutes the machine was saturated with wet from a deposit of dew, so that anything like a trial was impossible. I did not consider we could get the silk tight and rigid enough. Indeed, the framework altogether was too weak. The steam engine was the best part."*

1893

Sir Hiram Maxim, arms magnate and inventor of the machine gun, said: *"In 1887 I was approached by several wealthy gentlemen who asked me if I thought it was possible to make a flying machine. I said, 'Certainly. The domestic goose is able to fly, and cost and how long it would take, and, without a moment's hesitation, I said it would require my individual attention for five years, and might cost £100,000."*

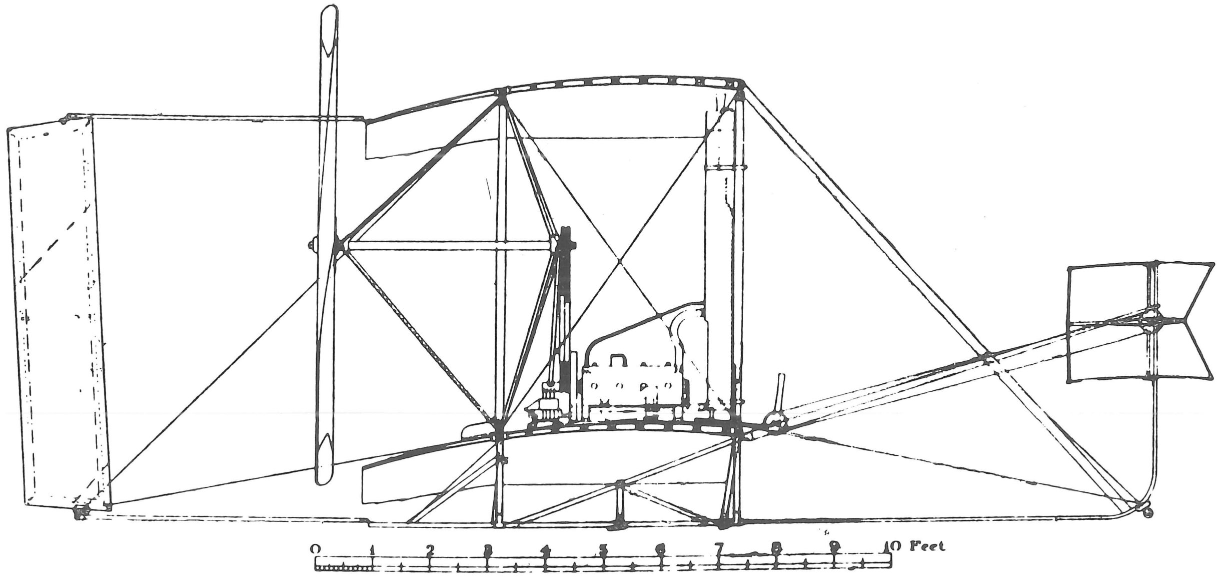
By 1893 the machine was complete, and ready for testing on a quarter mile runway in Maxim's private park. It was an enormous construction driven by two steam engines and weighing nearly four tons, with a wing span of 104 feet. Its runway was so constructed that the machine could not rise more than 2 feet from the ground. Maxim seems to have been satisfied with his results, for he sought the power rather than the skill of flight.



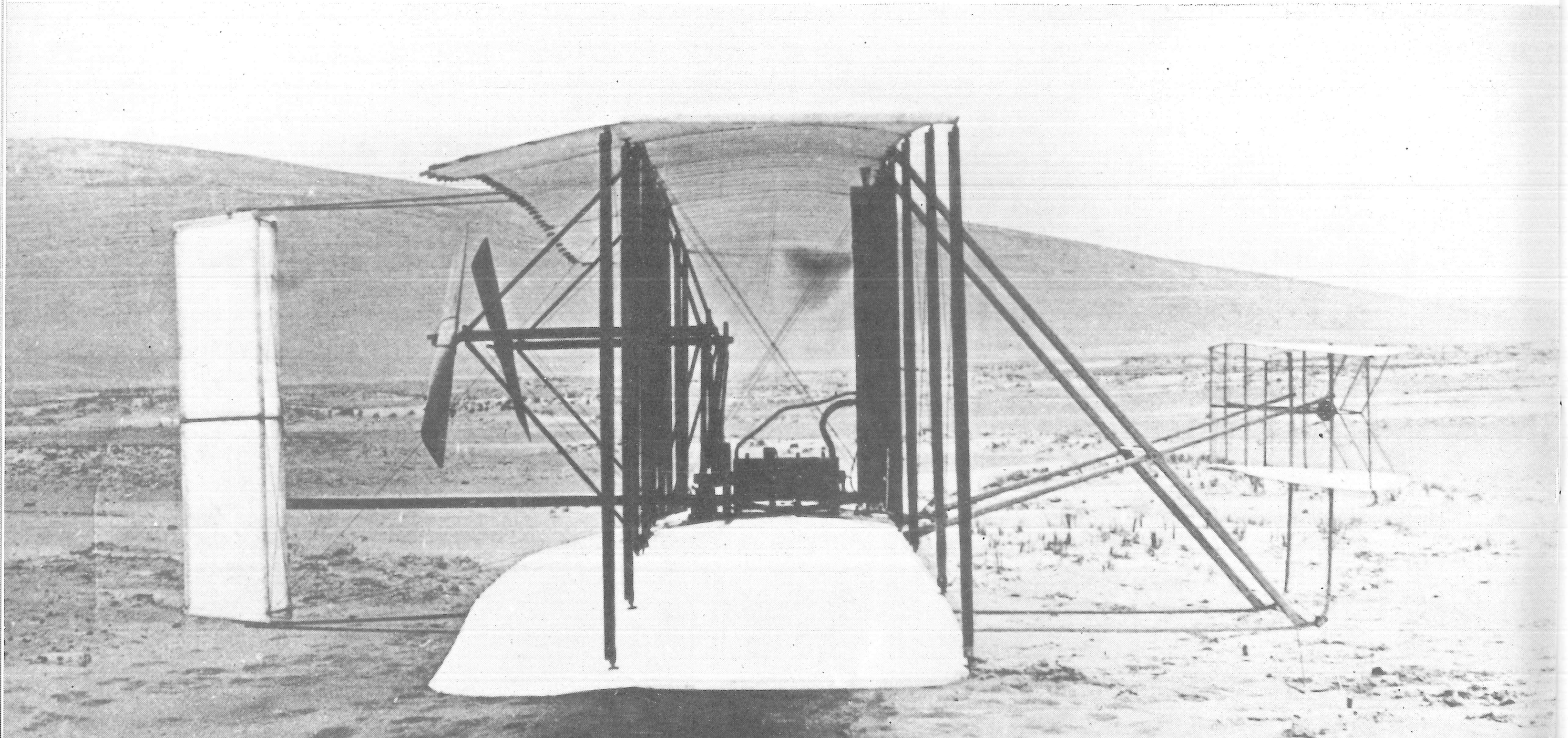
Courtesy of the Director of the Science Museum, South Kensington, England

"When everything was ready, with reliable observers stationed on each side of the track, the order was given to let go. The enormous screw thrust started the machine so quickly that it nearly threw the engineers off their feet, and the machine bounded over the track at a great rate. Upon noticing a slight diminution in the steam pressure I turned on more gas, when almost instantly the steam commenced to blow a steady blast from the small safety-valve, showing that the pressure was at least 320 lbs. in the pipes supplying the engine with steam. Before starting on this run, the wheels that were to engage the upper track were painted, and it was the duty of all my assistants to observe these wheels during the run, while another assistant watched the pressure gauges and dynagraphs. The first part of the track was up a slight incline, but the machine was lifted clear of the lower rails and all the top wheels were fully engaged on the upper track when about 600 feet had been covered. The speed rapidly increased, and when 900 feet had been covered, one of the rear axle-trees, which were of two-inch steel tubing, doubled up and set the rear of the machine completely free. The pencils ran completely across the cylinders of the dynagraphs and caught in the underneath end. The rear end of the machine, being set free, raised considerably above the track and swayed. At about 1,000 feet, the left forward wheel also got clear of the upper track, and shortly afterwards the right forward wheel tore up about 100 feet of the upper track. Steam was at once shut off and the machine sank directly to the earth, embedding the wheels in the soft turf without leaving any other marks, showing most conclusively that the machine was completely suspended in the air before it settled to the earth."

The machine was wrecked, and Maxim turned his attention to other things.



Courtesy of the Director of the Science Museum, South Kensington, England



Flight

By 1900 Lilienthal had developed, through his systematic gliding experiments, the skill of the flyer—the delicate adjustment between man and air movement.

Maxim the engineer saw flight largely in terms of power. His machine drove itself into the air like a projectile, but it could not fly.

It was the American Wright brothers who had both the acute care and the mechanical skill to fuse these two approaches in the first controlled power flight. This was achieved at Kitty Hawk, North Carolina, in December 1903.

Orville Wright describes the December flights: *"Faith in our calculations and the design of the first machine, based upon our tables of air pressures obtained by months of careful laboratory work, and confidence in our system of control developed by three years of actual experiences of balancing gliders in the air, had convinced us that the machine was capable of lifting and maintaining itself in the air, and that, with a little practice, it could be safely flown.*

"Wilbur having used his turn in the unsuccessful attempt on the fourteenth, the right to the first trial now belonged to me. After running the motor a few minutes to heat it up I released the wire that held the machine to the track, and the machine started forward into the wind. Wilbur ran at the side of the machine, holding the wing to balance it on the track. Unlike the start on the fourteenth, made in a calm, the machine, facing a 27 mile wind, started very slowly. Wilbur was able to stay with it till it lifted from the track after a forty foot run. The course of the flight up and down was exceedingly erratic, partly due to the irregularity of the air and partly to lack of experience in handling this machine. The control of the front rudder (actually the elevator) was difficult on account of its being balanced too near the centre. This gave it a tendency to turn itself when started, so that it turned too far on one side and then too far on the other. As a result, the machine would rise suddenly to about ten feet, and then as suddenly dart for the ground. A sudden dart when a little over a hundred feet from the end of the track, ended the flight.

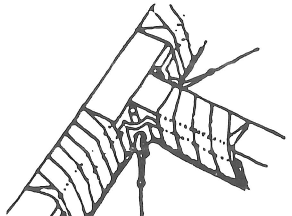
This flight lasted only twelve seconds, but it was nevertheless the first in the history of the world in which a machine carrying a man had raised itself by its own power into the air in full flight, had sailed forward without reduction of speed, and had finally landed at a point as high as that from which it had started. Only those who are acquainted with practical aeronautics can appreciate the difficulties of attempting the first trials of a flying machine in a 27 mile gale. As winter was already set in, we should have postponed our trials to a more favourable season, but for the fact that we were determined, before returning home, to know whether the machine possessed sufficient power to fly, sufficient strength to withstand the shock of landings, and sufficient capacity of control to make flight safe in boisterous winds as well as in calm air. When these points had been definitely established, we at once packed our goods, and returned home knowing that the age of the flying machine had come at last."

TECHNIQUES

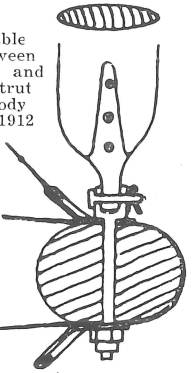
The Wright brothers' flights, in 1903, released unbelievable sources of excitement all over the world. Six years after their first success, aircraft were being built throughout Europe and America. The atmosphere of change and discovery allowed for no preconceptions of form—for the problem was an entirely new one calling for new uses of materials in totally new kinds of structure.

These early aircraft have the essential economy of all moving things— bicycles, gramophones, the cinematograph. Structures were needed which were lighter yet stronger than anything built before. Flyers' lives depended upon the planes they built which had to withstand, during flight, the vibration of the engine as well as the swing of stress during the change from one banking turn to another. Only by acting as a complete adjusting body could the structure respond to these varying stresses, and yet it frequently had to be taken to pieces and towed to a new landing-field.

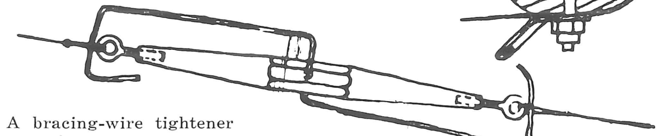
To answer these needs the aircraft builders eagerly accepted—and often actually invented—new materials and new methods of connection. Some of the earliest uses of light metal alloys and electric welding can be found in aircraft; but the first frames are mostly of timber: hickory, bamboo, ash, and other resilient woods. The whole structure is kept rigidly related by thin adjustable wires, and its timber struts, where they need complex and durable connection-points, end in neat metal casings. Sometimes even these are dispensed with, the members being bound tightly together with glued tape or thread. The frame was for many years exposed, and only the lifting surfaces were covered with tight, oiled silk.



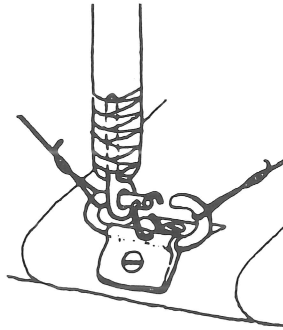
Main-frame joint metal angle bound to timber members with glue-soaked linen tape.



Demountable joint between wing-spar and vertical strut on the Cody Biplane, 1912



A bracing-wire tightener

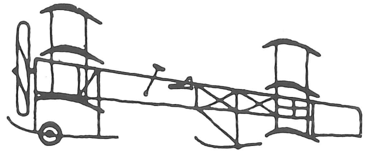


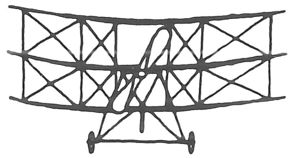
"Anybody accustomed to seeing a petrol motor run in a chassis, or on a bench, receives a shock on observing an engine start in the Wright aeroplane. It appears to bounce and wriggle about on the pliant frame. When it is running slowly at the start, it seems inevitable that its breaking adrift can be a matter of minutes only. Yet if you try to follow the vibrations to any extremity of the machine you will fail to do so. The shocks caused by the power pulses are quite absorbed before they reach the extremities of the main planes, or the flight path control planes forward, or the vertical rudders behind."—"Flight", 1909.

"What is required of the mechanic who takes in hand the work of aeroplane construction? He must be a perfect judge of wood, both with regard to its quality, its strength, and its suitability for the framework of the structure, and he must be able to manipulate that material with the most minute accuracy and in such a fashion as to secure a minimum of weight with a maximum of strength and durability."
"Flight", 1910.

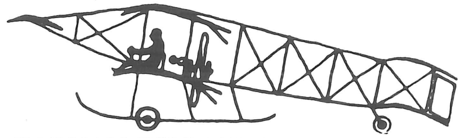
"In aerial work lightness in conjunction with strength is everything. Electric welding is especially suited to the joining of tubes and rods, which joints are effected without the use of lugs or brackets and are therefore as light as it is possible to make them."
"Flight", 1910.

These are four of the many machines at the Olympia Flight Exhibition of 1910. They were all constructed mainly in ash, and had a uniform control system of rudder, elevator, and warping wings.

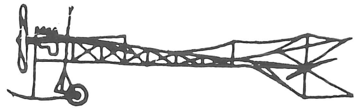




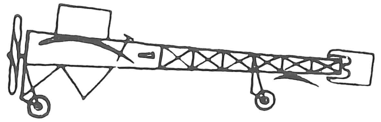
AVRO TRIPLANE/550 lbs
40 mph/35 h.p.

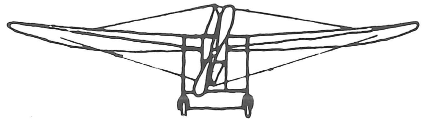


FARMAN BIPLANE/1,050 lbs.
40 mph/50 h.p.

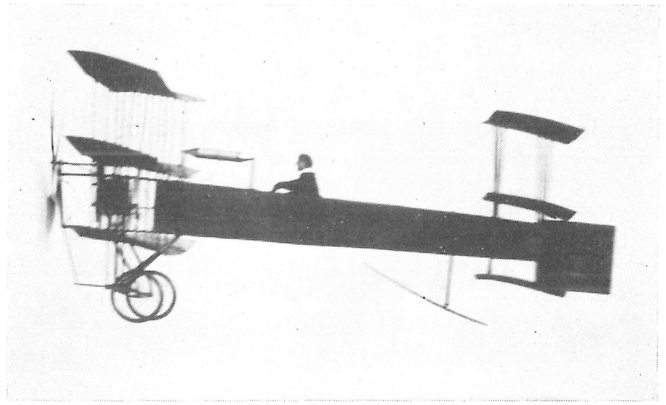


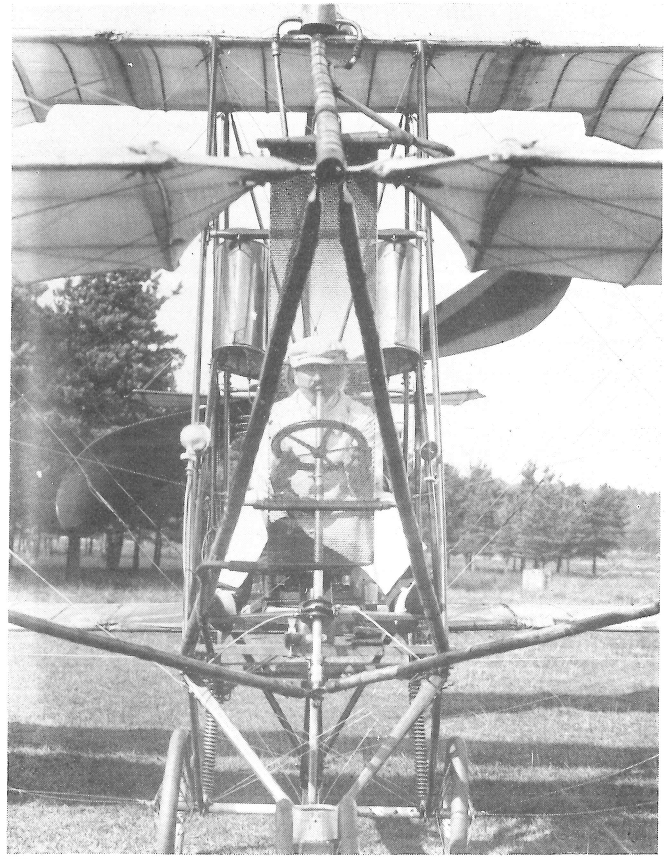
STAR MONOPLANE/750 lbs
36 mph/40 h.p.





BLERIOT MONOPLANE/660 lbs
40 mph/25 h.p.





Flight

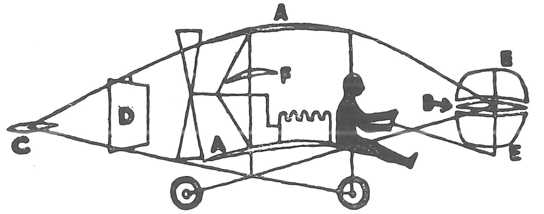
STABILITY

The problem of how to make an aircraft fly smoothly—that is, without rolling and pitching—is chiefly a matter of how the elements of flight—the surfaces for lift and control, the engine, airscrew, and landing gear—are related to one another in space.

By 1909 it had become clear that there were two different ways of approaching this problem. One was the amateur's way; it produced a multiplane machine that could change from day to day as new ideas came, that could easily be taken to pieces and quickly mended when it crashed. It was an adaptable rather than a fixed design. This method dispersed the mechanical problems and solved each separately—engine and airscrew, rudder, elevator and main planes were spread about the machine; compressive and tensile energies in the structure were conducted along separate paths and concentrated at many different points of connection; impact and vibration were absorbed not at localized points but through distortion of the whole structure; and the pilot hung on where he could like a bird in a cage.

The other method, which produced the monoplane and subsequently the commercial biplane, was the method of concentration. The aeroplane developed as a system of beams and cantilevers instead of a cage of wires and struts. Rudder and elevator were condensed into a tail unit separated from the engine and wings by a narrow girder, the fuselage. The wings were attached to this girder at two points and held in position by two sets of tension wires—one which hung the fuselage from the wings in flight, and one which hung the wings from the fuselage on the ground. The engine, airscrew, and landing gear, were all assembled in a single frame in front of the wings, and the pilot sat between them at the focal point of the whole machine.

This was the method of rationalisation, of perfection; the single inevitable solution, ready for mass-production, fit to fly the channel and incapable of further fundamental change.



multiplane

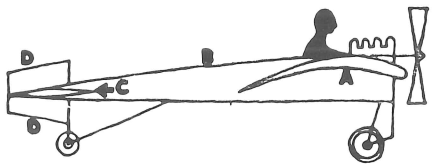
"(A) Main Planes: both single and double covered method is employed, the planes being superimposed and braced in the form of a lattice girder.

(B) The Elevator is usually constructed in a similar manner to the main planes. Although the initial function of the elevator is to assist in raising the machine from the ground, in actual flight it is used principally to damp longitudinal oscillations, the actual elevating being usually accomplished by varying the speed of the engine.

(C) The tail seems to be an accessory of doubtful utility.

(D) Is a vertical plane in line with rudder (E) to assist in directional steering.

(F) Airelons (now ailerons), which are used to obtain lateral stability, and take the place of flexing the main planes."



monoplane

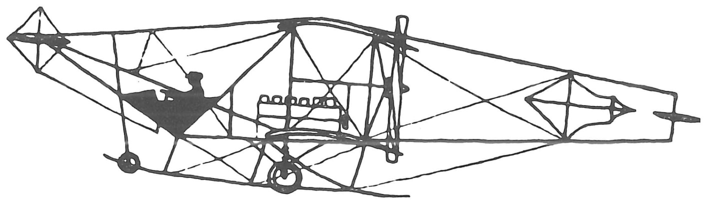
"(A) The Main Wings, which are in all cases double-covered.

(B) The Body: this being made up in the form of a lattice girder of box-section, of wood struts and wire ties, and is usually encased in fabric to reduce air-friction. When water-cooled engines are used the radiators are in most cases placed along the side of the body.

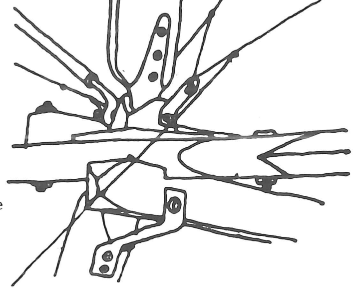
(C) The Elevator, is placed at the back of the machine, and in conjunction with rudder (D) forms the tail.

(D) It is probable that before long the vertical tail may be dispensed with, and side steering be effected by movement of the wings alone."

From "Design and Construction of Aeroplanes"—**Flight** 1910.



MR. CODY'S "CATHEDRAL" 1912—one of the last amateur machines



one of the four main junction-points of the frame

"The non-rigid type of biplane, with its extraordinarily simple and ingenious design for resisting shocks at those points where they are likely to be received, has really no need of coil springs, pneumatic shock dampers, combinations of levers and other guess contrivances. The scheme allows plenty of play, and you do not see anybody making wires taut as in the case of the rigid, French-built machines." "Flight" *1909.*

The multiplane v. monoplane controversy raged for years in the aircraft world and was too bitter a dispute to be explained on technical grounds alone. It was in fact symptomatic of two ways of looking at flying. For early experimenters the achievement of flight itself was everything, and efficiency far less important than the joy of taking one's own invention into the air. But now, from the enthusiastic chaos of the early years a more purposeful view was developing—the idea that the aeroplane could be "useful". Worlds like "responsibility" crept into addresses at aeronautical meetings, and the old fly-lovers tore their hair.

Bleriot, a successful manufacturer of motor car headlamps, personified this change. After early experiments he confined his work to refining a single idea—the monoplane—and from 1906 onwards his machines show a consistent development which contrasts strongly with the less rational love of flight of his contemporaries.

In the £1,000 Cross-Channel Competition of 1909 it is Latham, the amateur, who plunges with his untidy machine into the sea and Bleriot, almost unnoticed, who slips over the water in half-an-hour, lands precisely at Dover, on July 25, and collects the prize.

"Flight", June 19, 1909:

"So confident is Mr. Latham of his ability to cross the English Channel before very long, that he has, it is said, laid wagers to a very large amount that he will perform the feat before July 15. The actual place of crossing is still undecided, but he will probably start from some point between Calais and Boulogne, and he would like to land at Folkestone for, as he quaintly puts it, he 'has cousins there, and it would please them.'"

Meanwhile Bleriot, making cross-country practice flights in France, is quietly preparing for victory: *"Under fifty yards start sufficed to get the flyer aloft, and hardly had M. Bleriot passed the word that he was ready than he was flying along at a height of 25 meters above the ground. Off chased the three motor-cars in pursuit, and soon the cavalcade was spinning along over the highroad to Orleans, while Bleriot himself sped over hedges, ditches, fields and trees, as he cleaved his own course in a direct line for his destination. Presently the railway hove in sight and the locomotive of an approaching train whistled with all its might. Heads were thrust out of carriage windows, first in alarm, then in amazement. It was an inspiring moment as Bleriot, gracefully increasing* *his altitude to clear the telegraph wires, sailed calmly over the railway high above the train, waving his hand to the excited and cheering passengers. Having finished his journey M. Bleriot without delay proceeded to dismantle the machine."*

After days of waiting for good weather, Latham impatiently takes off and is over the sea, halfway to England:

"He was on the point of taking a photograph of his convoy the torpedo-destroyer 'Harpon', as it steamed furiously through the waters nearly 1,000 feet below, when he first heard his engine misfiring. 'Instantly I gave up my idea of photography', is Mr. Latham's first remark when commenting upon the incident. 'I examined all the electrical connections that were within my reach', he continues in the narrative he wrote for the 'Daily Mail'. *But, as he explains, 'I could hear that more than one of the eight cylinders was misfiring'. Affected by the recollection of the difficulty, Mr. Latham gives way at last to his first signs of feeling. 'It was maddening, but I was helpless. Never before had the engine played me such a trick after so short a flight.' Like all good sportsmen, Mr. Latham eccepted the inevitable and glided down to the surface of the water, for, as he succintly remarks, 'There was nothing else to be done.'"*

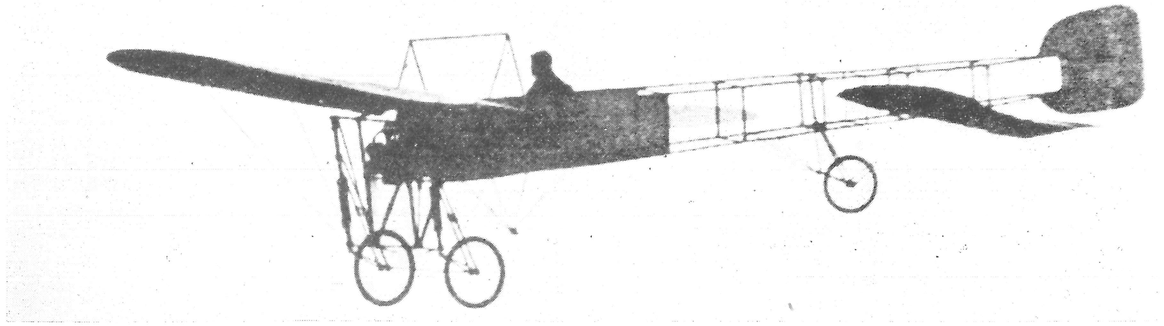
Taking advantage of a break in the weather, Bleriot sets off the next day:

"It was almost without warning, but nevertheless with a send-off on the French shore from an enthusiastic crowd, that M. Bleriot flew across the Straits of Dover on Sunday. His monoplane quickly outstripped the torpedo-boat destroyer 'Escopette' with which the French Government replaced the 'Harpon' that was on duty during Mr. Latham's attempt. In mid-channel M. Bleriot lost sight of land and of his escort for a very uncomfortably long period—estimated by him to have been ten minutes—and was entirely without means of ascertaining his proper direction. In the circumstances he did the only thing possible, which was to keep straight on:

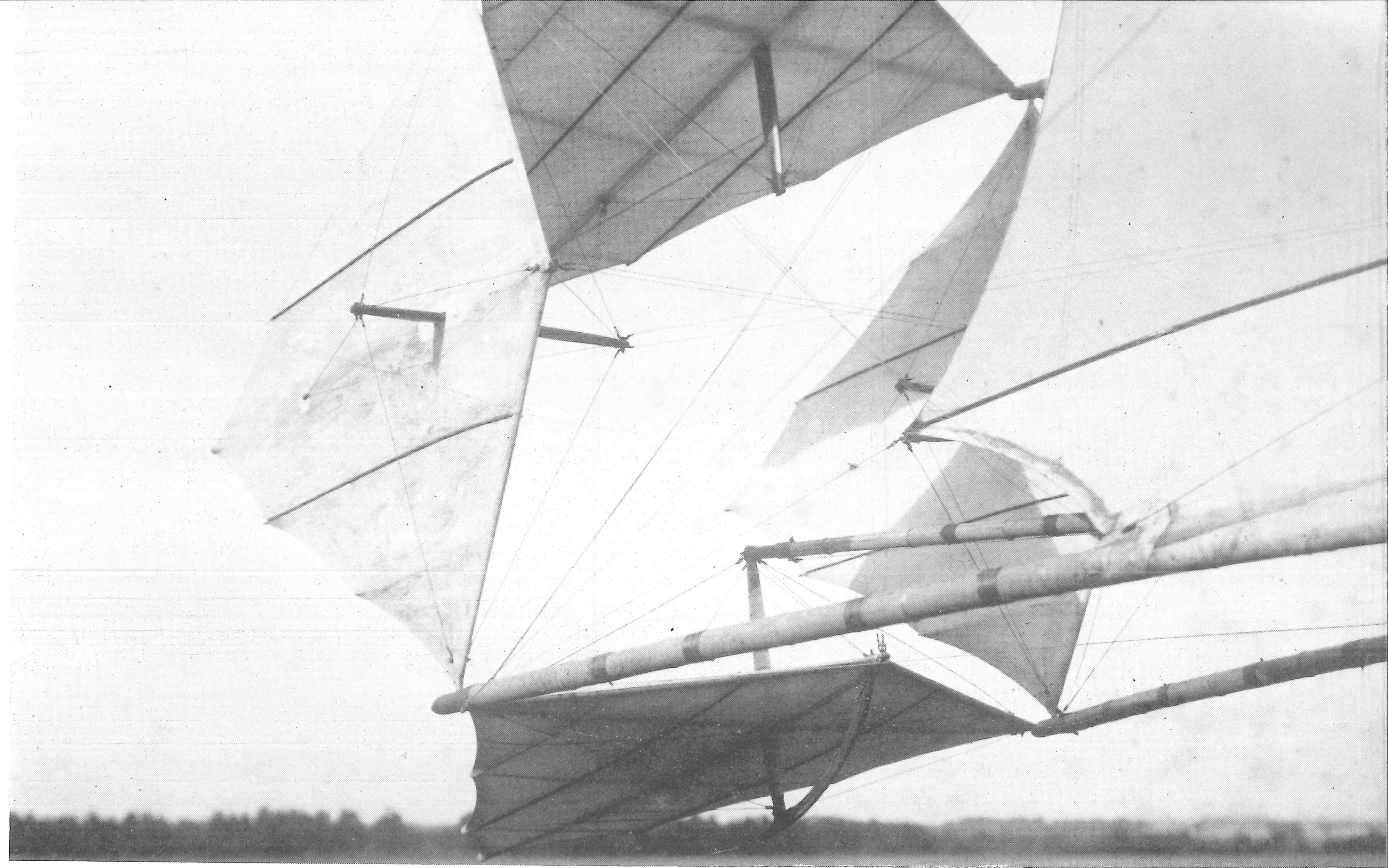
"'I touch nothing. My hands and feet rest lightly on the levers; I let the aeroplane take its own course. I care not whither it goes. For ten minutes I continue, neither rising, nor falling, nor turning. And then, twenty minutes after I have left the French coast, I see the green cliffs of Dover, the castle, and away to the west the spot where I had intended to land.

"'What can I do? It is evident that the wind has taken me out of my course. I am almost at St. Margaret's Bay and going in the direction of the Goodwin Sands.

"'Now it is time to attend to the steering. I press the lever with my foot and turn easily towards the west, reversing the direction in which I am traveling. Now, indeed, I am in difficulties, for the wind here by the cliffs is much stronger, and my speed is reduced as I fight against it. Yet my beautiful aeroplane responds. Still steadily I fly westwards, hoping to cross the harbour and reach the Shakespeare Cliff. Again the wind blows. I see an opening in the Cliffs.



Humber Company



Flight

"'Although I am confident that I can continue for an hour-and-a-half, that I might indeed return to Calais, I cannot resist the opportunity to make a landing upon this green spot.'

"He put in at a gap in the cliffs where a representative of 'Le Matin' was signalling to him with a tricolour flag. Although the arrival was noticed from afar by several, Police Constable Stanford was the only eye-witness of this great historic event—the landing on British soil of the first flyer to cross the Channel."

The sketch drawn by Bleriot tracing his journey across the Channel is potentially the large-scale control of flight in wartime operations rooms. Bleriot stood at the point of transition, for from that moment flight was predictable. Maps could be used, charts drawn, war and commerce transformed by this new vector of experience. The aeroplane was established as a social product, no longer the astonishing result of personal experiment and skill. And although this change is inevitable, something has been lost. Efficiency increases as forms crystallize, workshops grow into anonymous factories; variety yields to repetition.

It seems important that we should understand and feel for this early stage in the development of flying, whose sense we have tried to convey in this article. For in architecture, with the technical revolution at its height and new social forms emerging, we stand now on the threshold of an experience as new as that which welcomed the pioneers of flight. These men, faced with unheard-of possibilities and problems, gave themselves openly and confidently to a new experience. From their story we can learn to avoid, as they did not, the deadly anonymity of machine production wrongly used. With the same excitement and patience we can achieve, as they did, the perfect response to a new situation.

R. BUCKMINSTER FULLER

CONSIDERATIONS FOR A CURRICULUM

This is the second in a series of replies to a questionnaire sent to selected educators, scientists, philosophers, and engineers, by a special committee of the School of Design formed to make recommendations for a recent change in the curriculum. The preceding issue of this magazine presented the reply of the Italian engineer, Pier Luigi Nervi.

In speaking of "The Great Design" man refers to the a priori inventory of recognized events called "universe" and uses the word "design" *subjectively*. However man is unique amongst "living" phenomena in the degree to which he has advanced *objective* design participation in the evolutionary mutations of universe. By objective "design" I mean: conscious employment of experimentally discovered principles governing pattern modulation. Scientific generalization of the present inventory of discovered principles seemingly reduces modulations to a mutually permitted and required couple. This couple consists of *frequency* and *angle*. These may be independently *modulated* or *modified,* respectively, though constantly coexistant. The *frequency modulations* and the *angular modifications* employable by man may be applied by him to local or sub-system interactions of energetic universe. The local transformations thus integrated ever reactively (indirectly—inadvertently) accelerate irreversible total transformations of universe.

The following is a digest of my recommendations regarding the organization of a Graduate School of Design. I have separated the thoughts into direction, scope, and curricula. I have also elaborated mildly regarding the topics of the digest.

DIRECTION

Direction should be to aid the student in preparing himself to function in the industrializing world society as a competent initiator of patterns for increasing common advantage. This function catalyzes both *operative* and *potential* resources of all kinds into a realigned and realizable technology and management strategy, providing demonstrable increase in performance increments per units of invested resources. We will call this function the *Design Function.*

The design function is that of a science and art of *integration* of the excelerating omnidirectional penetrations of all specialization's differentiating functions. The "architect" is thus expanded as a function *from* that of a commanded servant, limited in his realizations by local resources, and subjectively reflexing his practiced diciplines in conventional solutions, *into* original and objective functioning as an initiator of comprehensive patterns, realizable in the terms of the unlimited resources of the energetic universe, as the latter is explored by pure science, and with priority of access to the first line tools of technology.

This function of original comprehensive patterning was performed throughout the last half millenium by the masters of world commerce, operating through political sources with their right hand and through private enterprise with their left hand, the accrediting and coordination of these two activities being alone integrated through the unpublished determinations of those masters. The world patterning by these masters of commerce, terminated between World War I and World War II when:

A) The monetary gold bullion, with which they controlled the pattern, became inadequate to the new orders of magnitude of wealth increments characterizing world industrialization.

B) The *sensorial* faculties of the individuals who had commanded the total contrived patterning became inadequate in appraising the new potentials of universal resources as opened up by the specialized extensions of science and technology into the *nonsensorial* reaches of the energy spectrum.

The condition (A) above is dramatically visible from our quarter century hindsight advantage of 1952, when we discover that whereas the 40 billion dollars approximate sum-total world supply of gold bullion employed by International Banking to cover all activity accrediting of the World pattern (and today retired to an artificial redeposited mine in the Kentucky hills) is dwarfed for instance by the 58 billion of active industrial-facility-command dollars, furnished by the population of the United States as "taxes" to their representative government in the one year 1952 to implement going expenses of its domestic and world patterning alone; while in the same year this United States population, which is only 6 per cent of the world population, produced 340 billion dollars worth of real produce, goods and services and initiated emergency defense expenditures of 70 billion dollars and extended 7 billion dollars of further capital initiation and prior access to technology's productivity as defense aid to peoples in other lands, and was further able to add 13 billion dollars to its bank account. All of this emergency articulation of resources was permitted as increment of the wealth over and above the personal income account of this 6 per cent of the world population, which is as yet only operating at the low level of 4 per cent over-all energy efficiency of total consumed annual industrial energy potential, yet which income account before these emergency expenditures bulks in hundreds of billions annually.

Clearly the integrity of the functioning of credit dollars has gone as abstract and beyond sensorial manipulation as has the mathematics which instruments the science, which in turn instruments the technology. The industrializing (sum-total) ephemeralizes as it goes rapidly from wire to wireless, track to trackless, pipe to pipeless, horse to horseless, pilot to pilotless, and now completes the abstract "plumbing," (i.e., the mathematical formulæ and technology) required to harness universal energy, and shunts the latter into preferred patterns of general man advantage.

In the last quarter century world society in general, and individual societies in particular, have found themselves operating in entirely new environmental integrations and with entirely new levels of realizable technological advantage. Yet it was gradually discovered that the old masters of comprehensive pattern, to which all other man-devised patterning had been subsidiary and sequential, had retired unannounced and that politically ambitious groups and individuals had sought to seize the released initiative. Because those same sensorial limitations which had rendered the masters of commerce inadequate also frustrated the ambitious politicians, a quarter of a century of political fumbling of the initiative has confronted world man with a dawning awareness of the need for a true *science* of comprehensive design.

Though democracy's prerogative has been thus frequently betrayed, such usurpation of authority into temporary dictatorships are baseless and always collapse.

Democracy, in historical fact, now alone has the fundamental authority over the industrial productivity. Industrial productivity ceases when the people as producer-consumers assert their will, but *authority* governs only *access to* the productivity. Authority cannot in itself produce, production must be initiated and iniation is inherently dependent upon the individual or a plurality of cooperating individuals. Democracy has vested its authority over prior access to productivity only in its military as a defensive or negatively subjective reflex action. Democracy can and may vest its authority of prior access to scientifically augmented degrees of productivity (industrialization) in positive or objective reflex pattern modulation. Its authority can accredit individual and cooperative pluralities of individually taken initiative.

Such a science of comprehensive design can be developed through the initiative of those who are custodians of cumulative intellectual and technical resources of man. These custodians are the universities. The task of developing graduate students in comprehensive design (as comprehenders of the principles permeating the plurality of sciences and arts and of the principles operative in the logistics of world resources processing) is superficially formidable, but clearly subject to solution. In the calculus integration is no more difficult than differentiation;—in industrialization, comprehensive patterning need be no more difficult in principle than successful specialization.

SCOPE

Numbers of students and ramification of their activity must be originally modest. No more should be attempted than is clearly seen to be profitable. Exploration of the new science and art of comprehensive designing must develop its own momentum as the individual is given every aid in self-development and initiative. Because the art and science is to be objective and original, its success must be predicated on the ability of the individual to take the initiative. If anyone can design the pattern for him, *that* latter designer *is* the comprehensive operator and the student is relapsing into *subjective* architectural functions. The individual student may, however, be given every aid in gaining access to the resources of the university within its gates and within its greater extramural scope. A handful of students, who can compare their experiences as an intimate team, would seem most appropriate to the opening of such a frontier.

CURRICULA

The curricula must of necessity be initiated by the students themselves with the aid of those chosen to staff the Graduate School of Design and must be developed experimentally in view of the new broad premises. Judgment of competence must be demonstrated by the students and measured by the initiative of those staffing the school. The staff must therefore be carefully chosen in relation to the breadth of the task.

There is documentation clearly visible of the increasing awareness of the need for the comprehensive designer. It is manifested in the multiplying want ads for a new kind of "Engineer",—placed by the many corporations,—covering the advanced phases of the industrial technology. These advertisements began nine months ago to ask for applicants in a category which is nonexistent in the formalized patterns of engineering art. The advertisements asked at first for "design engineers" and have come to shorten this description to "Designers" for inclusion in the engineering departments of their respective industries. What they mean to say is individuals who have competence, experience, and initiative beyond that of the formal engineering training.

In many recent case histories young graduates from Architectural and Product Design Schools with a meager preparation in the calculus, and structures, and mechanics, but with a considerable discipline in a wide range of technical strategies, and above all of encouragement in the development of their own resources and initiative, have been hired by those industries placing the advertisements for "designers" and have provided surprise solutions for problems which had frustated the conventional engineering personnel.

A further symptom of the dawning awareness of the need for the comprehensive designer is to be witnessed in the annual conferences undertaken in 1951 and '52 by the president of the Container Corporation at Aspen, Colorado, which brought leaders in American industrial management and designers for a week to consider "Design As A Function of Management."

Another large visible effect of the present absence of comprehensive designing activity is that evidenced by lack of any positive and published industrial management initiative taken in foreign policy concerning world integration of resources and facilities to eliminate conditions of inadequacy which in turn generate political reform solutions by various types of dictated socialism. A comprehensively designed foreign policy would remove trade barriers and would depend upon *design enterprise* to up the present number of customers of industrialization from 600 million to 2½ billion people.

Clearly the student of comprehensive design initiative will be faced with *all* problems and be concerned in directions of law, equity, economics, history, anthropology, semantics, government and public relations, in addition to chemistry, physics, mathematics, and all branches of engineering, and to the going management experience in upping the performance standards of industrial production and circulation.

I suggest that a first fundamental in advice by staff to Graduate Design students should be that the students study carefully the case histories of those individuals in history who *have* taken the initiative and have thereby won for man the great technical advantages over his a priori environment. The student should seek within these case histories principles common to all those initiators tasks. The students will gradually discern that a few principles (postulates) may be generalized from out of all these case histories and that these initiative-permeating principles are also in fact the core of mathematics and that they may be reapplied ever and again to special and general problems facing the comprehensive designer.

EDUARD F. SEKLER

BELIEFS BEHIND ARCHITECTURE

Eduard F. Sekler is an architect and city planner from Vienna, Austria. The following is a transcript of a talk he delivered at the School of Design.

Le Corbusier, explaining his system of proportioning "The Modulor" [1] relates how, in an early stage of his career, he became concerned with the whole problem of proportions: "At twenty-three, our man drew on his sketching board the facade of a house he was going to build. A perturbing question arose in his mind: What is the rule that orders, that connects all things? I am faced with a problem that is geometrical in nature; I am in the very midst of a phenomenon which is visual; I am present at the birth of something with a life of its own. By his claws shall the lion be known. Where is the claw, where the lion? . . . Great disquiet, much searching, many questions."

The feeling which Corbusier describes, uncertainty in the face of a predominately aesthetic choice must be familiar to most architects. It is comparatively easy, if one has enough time and application, to confirm those facts about a problem of design which are ascertainable by scientific method, or in other words, to design a building which will serve its purpose and stand up well. The difficulty begins if in addition the building is to have visual appeal and expressive qualities, if "delight" is added to "firmness and commodity."

It is here where intuition comes in as the architect's guide and indeed his stature as an architect will be determined in the last resort by his intuitive sensitivity. But can intuition alone be enough—or rather are there not factors which subtly influence the very functioning of the intuitive faculties because they colour the whole outlook of a man's life: his beliefs, his convictions and his modes of thought? Why have so many architects tried to formulate for themselves and others the guiding principles and criteria as to what is fine architecture, creating, so to say, yardsticks by which to check and measure their own intuition, looking for a principle of order that would be valid not only within but also without themselves?

These are questions which for too long a time have been neglected and which cannot be answered exhaustively in a brief essay. But it seems worth while, nevertheless, to outline at least some of the problems involved and to discuss briefly some of the spiritual principles which were underlying the architecture of the past and were motivating

[1] Le Corbusier, *The Modulor,* translated by P. de Francia & A. Bostock, Cambridge, Mass., 1954

forces of prime importance in shaping it; there is hope that in doing so we may even arrive at some conclusions relevant for our own time.

In pre-classical antiquity life was pervaded by a continuous awareness of the numinous, by a conviction that everything in the microcosm of man's terrestrial life had its parallel in the macrocosm of the universe. Man and his buildings were completely woven into the pattern of cosmic rhythms. Accordingly, architectural features had a symbolic signficance and every attempt was made to assure a propitious relation between the building and the cosmic forces by giving the building an orientation and proportions that were based on astronomical observations and astrological reasoning.[2]

In Egypt, the "pyramidal form of the king's tomb was of the most sacred significance" (Breasted) and the plans of sacred buildings were determined according to precepts contained in a holy book which was supposed to have fallen from heaven.[3] Measures seem to have had ritual implications, for in a hieroglyphic description of the temple at Edfou[4] certain passages of unclear but obviously ritual meaning are interpolated after each given measure such as "Its length is harmonical, it is 90 cubits, because he (the God) shines far . . . its width is 80 cubits, because he has united with himself . . ." In another passage the columnar court is likened to the Goddess of heaven and the entrance-pylon to the "two divine sisters, Isis and Nephtis, as they lift upward the disc of the Sun." (pl. 1)

At Edfou the Pharaoh himself is represented (pl. 2) setting out the main lines of the new temple. Assisted by a Goddess he holds cord and stakes whilst he speaks, "My regard follows the movement of the stars. If my eye has reached the constellation of the seven stars and the determined time is fulfilled . . . I fix the corner-points of your temple."[5]

Democritus, in the middle of the 5th Century, mentioned the Egyptian harpedonaptai—the cord-stretchers—and a striking parallel to their activity is afforded by that of the sūtradharas in India. They are those who hold the cord—the sūtra—when sacred structures, but also cities, towns and hamlets and other buildings, are laid out according to ritual diagrams that are full of astrological significance. Since "the temple is built in the likeness of the universe and is its reduced image" there is not a single element which is arbitrary in dimension or position or without a meaning for the faithful. "When the Gods are set up with correct proportions then they can be worshipped."[6]

[2] Phyllis Ackermann, The Symbolic Sources of Some Architectural Elements, *Journal of the Society of Architectural Historians*, XII/1953, No. 4, 3ff.

[3] E. Baldwin Smith, *Egyptian Architecture*, New York 1938,231

[4] H. Brugsch, Bau und Maasse des Tempels von Edfu, *Zeitschrift F. Aegyptische Sprache u. Altertumskunde*, IX, 1871, 138

[5] H. Brugsch, op.cit., VIII, 1870, 154

[6] Stella Kramrisch, *The Hindu Temple*, Calcutta 1946, 227

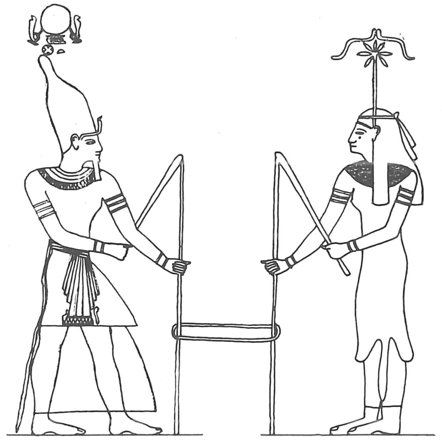


Plate 1

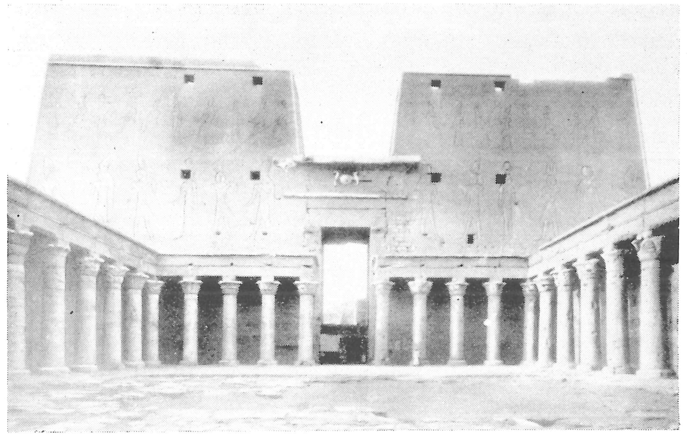


Plate 2

In classical antiquity, unfortunately, we are faced with the fact that no written evidence has survived about the symbolic meaning of architectural elements or about systems of proportions that were applied and charged with a spiritual significance. There can be little doubt, however, that such systems existed and that certain geometrical principles which guided the design had cultic implications. From very early times certain ratios of the length to the width of a temple were dedicated to certain deities such as 3:8 to Hera, 2:5 to Appolo, 5:11 to Zeus, and in the fifth Century B.C. the whole design of the Doric temple became governed by the strict application of a coherent system of proportions.[7]

It would seem a very odd coincidence that this should have happened in architecture just at the same time when the Pythagorean school of philosophy evolved its mystical theory of numbers as the elements of all things. From Pythagoras' discovery that musical consonances can be expressed by simple numerical relations (1:2 an octave, 2:3 a fifth, 3:4 a fourth), and that thus a palpable connection between phenomena in the visual and the audible world could be established, it was only a step to the belief that the law of the secret harmony of the universe had been found, a harmony pervading everything including man, and revealed in certain sequences of numbers. Plato in his *Timæus* has left us the most complete and beautiful exposition of this creed. It is significant that he ranks those arts highest which are based on measurement and order, and maintains that there is no beauty without measure.

Such conceptions were of the highest importance for architecture. Henceforth they were never quite lost sight of and although they were not always grasped with all their

[7] Max Theuer, *Der griechisch-dorische Peripteraltempel*, Vienna 1918

implications, a high esteem of geometry remained prevailing; geometry not only as a scientific tool in design but as a formal expression of its metaphysical background.

We do not know to what extent the strict orientation of the two axial main streets of Roman camps and towns was conditioned by a ritual procedure for when Vitruvius wrote the only treatise on the architecture of classical antiquity which has survived he refrained from expounding the deeper meaning of some of the things which he mentioned, quoting Greek authorities all of which, unfortunately, are lost. Yet he often speaks of symmetry, eurhythmy and proportion as guiding principles, using the original sense of the word symmetry as regularity and commensurability of form. Thus in the third book he explains that the designing of temples "depends on symmetry and proportion . . . . worked out after the members of a finely shaped human body." Here for the first time to our knowledge the proportions of the human body are likened to those of a building.

In the book of Vitruvius the classical tradition concerning proportions and harmony was preserved for the Middle Ages and the Renaissance. Moreover Plato's *Timæus* itself was one of the classical writings which had, together with those of Aristotle, a direct impact on patristic thinking and thus nourished the spiritual roots of mediæval architecture. Although there is no doubt whatsoever about the presence of a spiritual background in mediæval architecture, we encounter considerable difficulties as soon as we try to establish the exact relationship between thought and its three-dimensional manifestation in individual cases. Among a variety of possible approaches the following three seem to be the most promising.

One of them is a general comparison of mediæval philosophy and architecture in order to show genuine parallelisms and contacts in their evolution and coexistance: a comparison between a great structure of the mind such as a *Summa Theologiæ* with a great structure materialized in three dimensions, such as a cathedral. In this context Professor Panovsky points out how the mental habits induced by scholasticism affected the formation of Gothic architecture.[8] How, for example, the unprecedented manner in which structural elements are shown (pl. 3) and in which "the interior space projects itself, as it were, through the encompassing structure" finds its parallel in scholastic writing, where the aim is elucidation and clarification in matters of content and formal presentation. In a similar manner parallels are drawn between architecture and scholasticism regarding the "arrangement according to a system of homologous parts and parts of parts," "distinctness and deductive cogency" and "the acceptance and ultimate reconciliation of contradictory possibilities".

[8] Erwin Panofsky, *Gothic Architecture and Scholasticism*, Latrobe, Pa., 1951

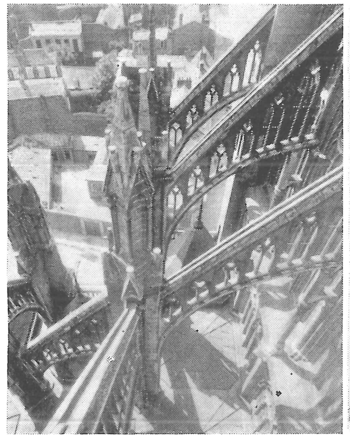


Plate 3

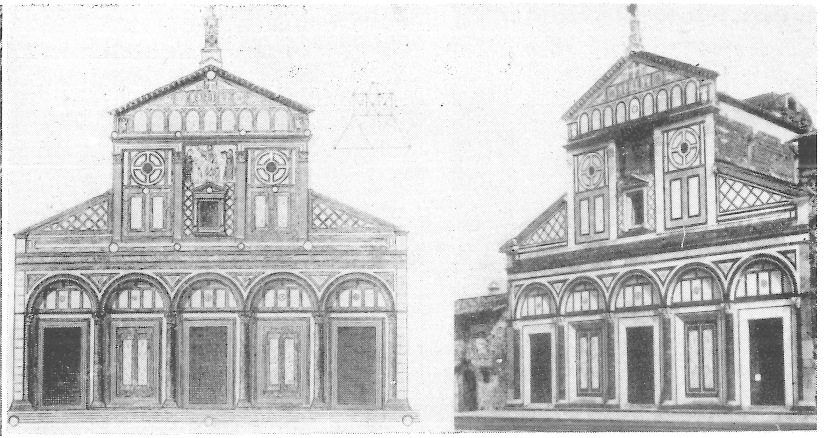


Plate 4

But whilst all this is based on later analysis and interpretation, lucid and convincing as it may be, there is a considerable amount of mediæval source-material available if the attention is focused on the symbolic and iconological meaning of mediæval architecture.[9]

Many statements in the writings of mediæval clerics such as Abbot Suger of St. Denis, Honorius, Durandus and Sicardus make it clear that to them the whole fabric of a church was full of symbolic significance as the terrestrial representation of the heavenly city. While the symbolism of the cross-shaped plan is self-evident, the circle in the plan of a centrally planned church was to remind the faithful "That the church is to expand into the whole world and that from the terrestrial circle we are to strive for the heavenly crown." An elaborate number symbolism prevailed and most architectural features had more than a purely formal or structural meaning, from the stones of the fabric which represented the individual members of the church held together by the mortar of heavenly love to the covering vault and dome which recalled the very dome of heaven itself, the celestial sphere.[10]

Finally a third approach consists in the interpretation of evidence that has survived about the mediæval use of geometry in building and about its hieratic meaning. It has long been recognized how important a part geometry played before and especially during the Gothic period (pl. 4)[11], when the square and the equilateral triangle are mentioned as guiding figures in such mediæval sources as the documents relating to the construction of Milano Cathedral in the 14th Century[12] and in the little book by the master

[9] Guenther Bandmann, *Mittelalerliche Architektur als Bedeutungstraeger*, Berlin 1951
[10] K. Lehmann, The Dome of Heaven, *Art Bulletin*, XXVII, 1945
E. Baldwin Smith, *The Dome etc.*, Princeton 1950
[11] Matila Ghyka, *The Geometry of Art and Life*, New York 1946
[12] J. Ackerman, Ars sine scientia nihil est etc., *Art Bulletin*, XXXI, 1949, 84

mason, Matthæus Roriczer, *"Von der Fialen Gerechtigkeit* (Regensburg, 1484)[13]. Geometry here was more than a practical tool or an æsthetic principle. It was a revelation of the Divine Order of Creation[14]. "Omnia in mensura et numero et pondere disposuisti" (Thou hast ordered all things in measure and number and weight) this passage from the Book of Wisdom (II, 21) was paraphrased by many mediæval minds in a manner extremely relevant in our connection. Harking back to St. Augustine's "All Beauty rests on number," Isidore of Seville writes in the 7th Century "Take the number out of all things and all things perish," and an anonymous German poet finally states with beautiful simplicity: "Gott hat allen Dingen geben Masz nach dem sie sollen leben" (God has given measure to all things according to which they are to live). Under this aspect we understand why rigid schemes of proportion so often governed Cistercian church architecture, as at Fontenay, and why the symbolism of mediæval masons' lodges—"Bauhuetten"—seems to have been based on geometry entirely in the same manner as their masons' marks were based on simple geometrical key figures (pl. 5)[15].

The same method which governed the setting out of one group of masons' marks, of tracery and, as Roriczer's book explained, the design of finials—the "quadratura" or squaring—was equally applied to other elements of architecture. This has been established recently for a number of mediæval plans and buildings, among them the Minster at Freiburg in Germany[16]. A comparison of the preserved drawing for its tower and

[13] P. Frankl, The Secret of the Mediaeval Masons, *Art Bulletin*, XXVII, 1945, 51

[14] O. G. von Simson, Wirkungen des christlichen Platonismus auf die Entstehung der Gotik, in *Humanismus, Mystik u. Junst d. Mittelalters*, J. Koch edit., Leiden-Koeln

[15] R. Rziha, Studien ueber Steinmetzzeichen, *Mittlgn. d.K.K. Central*, 1953, 159 *Commission etc.*, Vienna 1881, vol. VII, 26ff.

[16] Maria Velte, *Die Anwendung der Quadratur etc.*, (Dissertation), Basel 1951

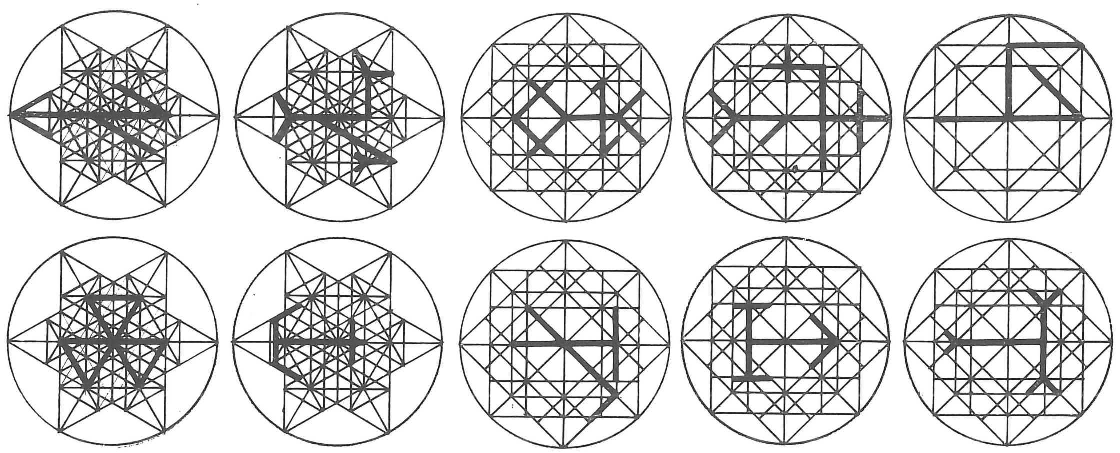


Plate 5

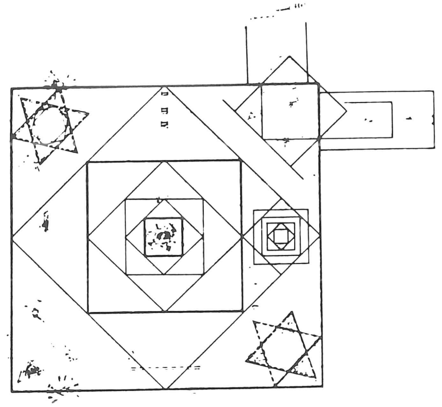


Plate 6

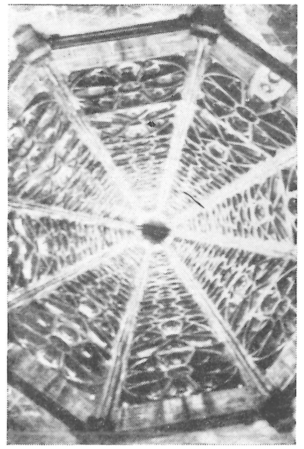


Plate 7

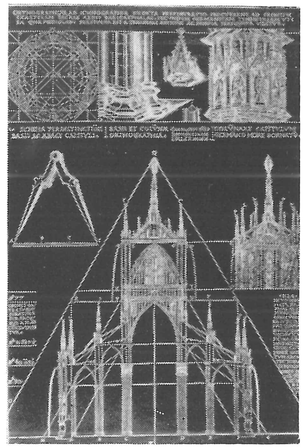


Plate 8

steeple (pl. 6) with the executed structure (pl. 7) shows convincingly that the wonderful richness of Gothic architecture is not the result of arbitrary design based on æsthetic considerations alone, but of an inner order based on geometry which was full of transcendental significance. Thus a beauty originated which might truly be defined by a phrase ascribed to St. Augustine as "splendor ordinis"—the splendor of order.

At the advent of the Renaissance, geometry, charged with a deep significance, still remained a most important element of design. The pages of the theorists are full of it, and men like Francesco di Giorgio and Caesare Cæsariano were endeavoring to achieve a synthesis of mediæval and Vitruvian percepts. Thus Cæsariano, in his edition and commentary of Vitruvius (Como, 1521), still shows the mediæval geometrical diagrams in connection with Milano Cathedral and explains the setting out of base and capital of a Gothic pillar (pl. 8). But like Francesco di Giorgio he also re-interprets the Vitruvian idea of taking a system of proportions from man's body, enframed into the perfect figures of circle and square (pl. 9). The underlying idea of this and similar anthropomorphic schemes was that the microcosm of man's body, as the most noble work of the Divine Creator, mirrored the harmony of the macrocosm and thus could give a clue to the perfect proportions of a building. Together with this the whole complex of Pythagorean and Platonic thought came to life again and formed a vital basis of the new style, as has been shown by Professor Wittkower[17]. Not only in sacred architecture but also in secular work the age-old belief was at work again that it is possible for man to integrate his building into the greater harmony of the cosmos by choosing certain proportions which are, as it were, in tune with it. In this sense Palladio's system of proportions is to be understood which he laid down in the pages of his *"Quattro Libri."* When his

[17] Rudolph Wittkower, *Architectural Principles in the Age of Humanism*, London 1949

friend and patron Daniele Barbaro remarks in his commentary to Vitruvius that proportion is general and universal "in all things given to measure, weight and number" he recalls to our minds that whole world of order which lay behind these words for such a long time; an order which had seemed unalterable but which gradually began to change as man started to penetrate deeper into the secrets of nature.

"Numero, pondere et mensura"—it is more than a mere coincidence that Sir Christopher Wren chose these words as his motto, though for him standing at the threshold of a new age their meaning may already have been different. Geometrical guiding principles can still be found in many of his plans, including that for St. Paul's Cathedral (pl. 10-12)[18], but it is no longer clear how far they were still charged with a spiritual meaning for him. It is true he speaks of God as the greatest and best geometer who reveals himself in the cosmic order, and believes in an unalterable geometrical beauty, but he must also have been in sympathy with his contemporary and fellow scientist in France, Charles Perrault, who, in 1683, wrote the following momentous words with regard to proportions: "They have only been arrived at by an agreement of the architects who imitated their works one from the other . . . they are not certain and unchangeable as in music."

With this statement a new architectural era can be said to begin, in spite of the rather disappointing academic consequences which at first were drawn from it. For here, for once and forever, a dam was broken that could not be rebuilt, a faith destroyed that could not be revived in spite of the efforts of classicists like Blondel. In the 18th Century there are still examples of symbolism in architecture[19] but on the whole geometry loses any deeper meaning and becomes a mere tool to be mastered rationally. Architects could no longer be convinced that they were in the possession of a certain knowledge of what was beautiful because it was in accordance with the cosmic order; they had to rely instead on their subjective taste and on the judgment of their contemporaries. It is here where the important psychological consequence comes in which is still relevant today.

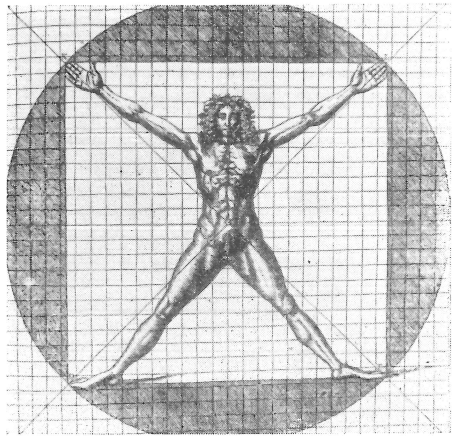


Plate 9

[18] The entire geometrical diagram shown on pl. 12 can be derived in stages from a simple subdivision of the square of the choir (pl. 11) which is based on a method shown by Serlio at the end of his first book (pl. 10). A detailed discussion of this will be found in a forthcoming book: *Sir Christopher Wren and his Place in European Architecture.*

[19] E. G. the churches at Kappel, Bavaria (1685-89) and at Stadl Paura near Lambach, Upper Austria (1721-22), based on the equilateral triangle and dedicated to the Holy Trinity.

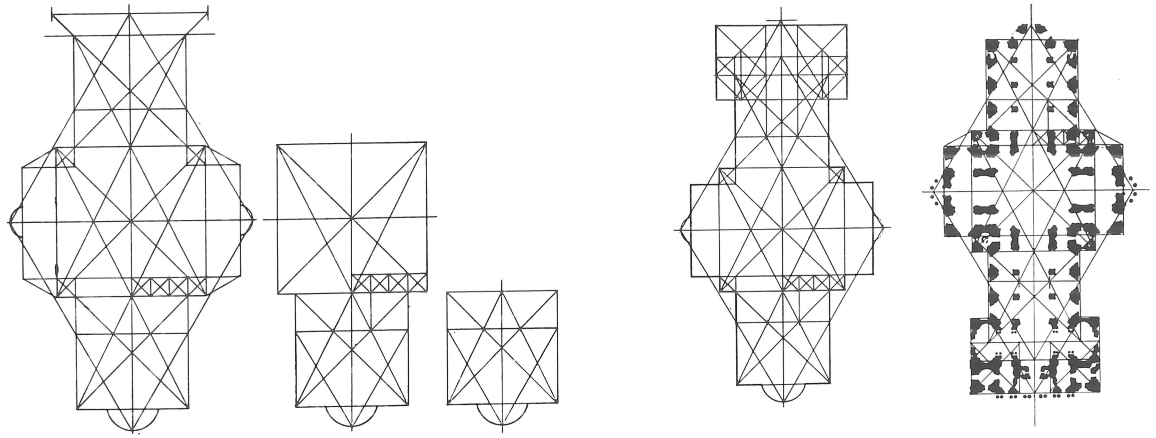


Plate 10-12

Proportions and geometry as bases of design were not important in themselves, nor were they a panacea for the production of fine architecture, as many a sterile academical building shows which was designed with a strict adherence to a system of proportions. What mattered was whether the architect believed that his design was integrated in a greater system on a metaphysical basis. If he was convinced that he and his work were part of a greater harmony beyond the horizon of everyday needs and considerations, this creed gave him not only the humility but also the unshakeable assurance which are so much safer foundations than any personal idiosyncrasies. It is a truism that someone with a strong conviction, however "wrong" it may be, has a great advantage over anyone with none.

It will be our task now to make an attempt to trace such modern habits of thought and doctrines as may be relevant to the architecture which has been coming into existence since the beginning of our Century. Obviously, our conclusions here will be scantier and more liable to error than in our retrospective survey since we lack distance and detachment. At the outset it may be useful to determine which is our attitude to the most powerful beliefs behind the architecture of the past. There we found basically two convictions, closely linked together. On the one hand there was the belief that a harmony of the cosmos existed as an expression of Divine Order and that it was possible to bring a building into concordance with it by means of orientation and proportion. On the other hand the anthropomorphic approach to architecture prevailed, the conviction prevailed, the conviction that man's proportions and attitudes should be echoed in architecture since man's body mirrored the universal harmony. Both these convictions were of a transcendental nature and implied a symbolic content of all architectural forms which therefore could not be chosen arbitrarily. All architecture of the past had, in fact, transcendental roots at first; whether it was monumental architecture for the Gods, for the deceased or for the rulers who held their powers from the Gods; or whether it was domestic architecture creating in the home not only the primordial place of living but also of cult, and interchanging continuously forms with monumental architecture.

None of these old convictions are valid any longer in their full traditional sense in our time. We feel uneasy when faced with the monumental, and the old symbols have lost their power; we may still be aware of their meaning, but it is an intellectual and associative awareness that has no motivating power in our life. Nor can we, with our increased knowledge in the domain of number, weight and measure, be satisfied by the old concepts of a static harmony in macrocosm and microcosm. We cannot accord other than purely æsthetic qualities to proportions.

Scientific method and attitude have done away with these old beliefs; they are the most powerful factors influences our mode of thinking and reacting. Yet if we consider the results of our penetration into microcosm and macrocosm, from the atom to the spiral nebulæ, it appears as if there were some archethoughts of humanity which, once conceived, remain valid. Thus we return to concept of an all-pervading order in the universe guided by physicists like Einstein and Planck who make us realize the fundamental unity of all existence in a system where energy and mass are interchangeable. We also try to re-establish concordance between our buildings and the nature around us. It would seem to be one-sided to account for this by utilitarian reasons of insulation, exposure and so on alone. Rather, is it not, that we feel the need to be part again of nature's reassuring perennial rhythm? Finally we have re-affirmed man as the measure of all things, and we are much pre-occupied with all the sciences directly concerned with his life, from biology and physiology to psychology and sociology.

If there is something new, though not completely unprecedented, in all this it seems to be the dynamic nature of the order and harmony which we discover. We deal with forces and movements, processes and changing patterns, not with a static hierarchy of facts and actions as in times past. *Panta rhei* — "everything is in flow", Herkalith's saying assumes a new meaning in our time where the definite and the absolute, death and power, no longer are the prime motivating forces behind architecture, but rather life itself.

Once we have realized that today, as always, architecture is a faithful expression of the philosophical and spiritual climate of a period, many phenomena in contemporary architecture which so far have been considered in terms of technology, fulfillment of purpose and æsthetics alone, will assume a new meaning for us.

RICHARD J. NEUTRA

PHILOSOPHY OF STRUCTURES

Our first experience of stress, the subject matter of engineers and engineering is quite "natural." Our prototype of this experience is exemplified by the strains, the tensions, and the pressures in our own body, in our limbs and muscle packs. The triumph over gravity may have been spectacularly dramatized by great architects of various ages but an infant turning toddler, standing up on his little legs, gathers his first, most intimate, most first-hand knowledge about the pull of the earth and about strains and stresses.

If we later in life and in professional engineering practice progress in related knowledge and perform on the basis of ever new findings, the primary basis for our penetration into this subject of "stress" is our inner perception our inner sensings, which report to us every fraction of a second on the position and posture of our own body, the stress-distribution within it, the temporary deformations which outer mechanical forces, above all gravity, may work on it.

Great psychiatrists and experts in nervous physiology, like Dr. Paul Shilder, have led me to a new recognition of that great and general significance which our own body image subconsciously holds for our entire outlook on the physical world and in particular on man-made structures around us. One could claim that our understanding of the world and its structures is "anthropomorphic." We identify ourselves with rocks, trees, with beams and columns, and thus we understand them, their static balance or dynamically disturbed equilibrium.

J. J. Polivka, who introduces his great Spanish colleague and friend Eduardo Torroja to American readers, believes himself in the "empathy," the "infeeling," which accompanies great engineering divination. Leading designers like Torroja and Polivka, like Freyssinet, Maillart, Dishinger, Nervi, intuitively partake in the inner conditions of their created and formed structures.

Polivka, himself author of well known engineering projects in Europe and this country, co-worker of first rate architects in both hemispheres, a writer of great experience, appears the logical person to introduce the famous Spaniard to us. And it happens at a period when a young generation feels jaded by humdrum repetition of old architectural clichés never clearly to escape from two-dimensional static concepts.

True enough, every structure is three-dimensional, as is the space which it encloses, but keeping away from the monopoly of isolated cross-sections, carrying into design a fused "Gestalt" in space, a spatial shape, has been hindered by the planimetric paper tradition and the initial oversimplification of yesterday's "calculated engineering."

In the "dark middle ages" when paper was scarce and shapes like vaulted ceilings of lofty cathedrals moved without much intermediate draftsmanship right into reality under the hands of creative workmen, the wisdom of our great engineers of today was foreshadowed. Stone quoins and bricks were neatly prefabricated, hoisted and assembled in phantastic integration.

Yet with all our interest in prefabrication and gratitude for its ingenious progress, we must acknowledge the indebtedness of our period to the stimulation which the "one-cast," the continuous, the monolithic reinforced concrete construction has yielded. A new wave of integrated shape imagery started from there, like in Torroja's Fronton Recoletos in Madrid or Dischinger's wide-span, thin-shell domes of the market buildings in Leipsic and Bale.

America, the country of great and daily engineering know-how, of streamlined structural procedure and speculative comprehension of its implications in a many-faceted mind like that of Buckminster Fuller's—should and will welcome Torroja's Philosophy of structures which Jaroslav Polivka presents.

GEORGE BOAS

THE PETRIFICATION OF FORMS

George Boas is a member of the Department of Philosophy at Johns Hopkin University and for the past two years has conducted a course in Philosophy of Design with the fifth year students of the School of Design.

The history of art is the struggle between two tendencies, the tendency to conserve and the tendency to innovate. These tendencies appear in the life of an individual as well as in that of society. One does not have to have lived very long before certain ways of satisfying one's desires become habitual: having meals at a specified time; wearing certain clothes for play, for dressing up, for church, for school, for sleeping and for waking; speaking in formal or informal English as the occasion demands, using the vocabulary of the Gang or one's Elders or one's Teachers, talking baby-talk to babies and man-talk to one's contempories; playing games which are played by one's friends and playing them according to the rules. Before long such patterns of behaviour become compulsive and the youth seldom has to question the rightness of them. They have taken on an aura of correctness, violence to which would leave one with a feeling of guilt. The individual's way of living becomes an integral part of his character and when questioned about why he acts as he does, his most truthful answer would be, "This is the way I was taught to behave."

All this simply means that any type of behaviour can become habitual, whether upon examination it makes any "sense" or not. "Sense" in this context means utility or reasonableness. There is no sense in using two kinds of language, one for instance, when one is ceremonious and the other informal, if we assume that the purpose of the language is communication. For one can communicate one's ideas quite as well in informal language, slang, solecism, and barbarism as in the nobler forms of speech and indeed the only way to judge the utility of one's speech is by its success or failure. But the minute such reflections arise, it is clear that one can judge nothing which involves other people without considering the social context in which such acts occur. In other words, using "bad" language on "good" occasions may turn out to be as effective as using "good" language; but the value of one's speech will not be judged by its utility but rather by the approval or disapproval of the social group to which one belongs. This does not imply that one belongs to only one social group. But no communication goes on outside of a social group of some sort, even when a person is talking to himself. Perhaps the best way of discovering what a person actually is way down deep would be to listen to him when he is talking to himself. But that obviously is impossible outside of a psychiatrist's office.

This brings us to the question of why society—a term which I am using to mean the little social groups as well as the big—approves of certain ways of satisfying our desires, needs, appetites, drives, and interests and disapproves of others. Every attempt which has been made to date to explain on the basis of utility such systems of approbation has failed. Food taboos in so-called primitive societies have been explained as due to dietetic reasons, but two neighboring tribes who live in similar circumstances may have radically different taboos. Yet if one tribe forbids the eating of fish and another does not and both live in a climate in which, for instance, fish deteriorates quickly, hygienic reasons cannot explain the taboo. Our respect for private property, incorporated in the Decalogue, does not apply in certain college communities and even in certain large families where the using of other people's clothes, typewriters, and on occasions money, is not considered stealing. In a communal society, such as those of some of the Polynesian islands, the results of one's work—the fishing catch—are not believed to be private property but are distributed by the headman of the village according to need. But at the same time other things are seen to be private possessions, one's tools, for instance, and sometimes one's land. Even in our own industrial society where we believe private property to be almost sacred, the government is permitted by common agreement to levy taxes and however much we may complain about the amount of our property so taken, we do not usually object to the principle of taxation. Hence it is wiser to conclude that utility is not the basis of our social systems of approbation.

On the other hand we may suspect that in an earlier period of our history such systems did have such meaning. If one runs through the Bill of Rights one discovers certain rights, such as the right to bear arms, which seem almost obsolete. The right not to have soldiers billeted in private houses during times of peace no longer seems important to us for the simple reason that no government would be likely to consider billeting at such times as effective housing for the military. Presumably the authors of the first Ten Amendments to the constitution did believe such rights to be important; otherwise they would not have gone to the trouble of listing them. Such matters are not of course examples of inexplicable customs or traditions, but are simply instances of how a right may be determined for reasons which become less forceful as years go by. There are, however, other traditions whose origin is no longer known. I refer to family organization as a single example. It may seem to the unitiated that all peoples organize their families with a paternal head whose power over his wife and children is absolute. But the most rudimentary knowledge of cultural anthropology will dispel this illusion. We have matriarchal as well as patriarchal families, families where the maternal uncle has more power over a woman's children than their biological father, families which are "extended" to such a point that one's duties spread well beyond those individuals whom we in modern America are accustomed to think of as our kith and kin. The peculiarity of our custom of family organization may be seen in the growth of women's emancipation. It is even doubtful whether religiously minded men and women would follow the dictates of Saint Paul when he speaks of the relation between wife and husband. In France it was not until the end of the Second World War that wives were permitted to own and dispose of property, to have their own bank accounts, and to vote. Here then is a custom whose force is weakening, whether one believes that it should weaken or not, and I imagine that if my juniors would read Paul's First Epistle to the Corinthians (especially Ch. 7 and Ch. 11, 3) they would be amazed that only two thousand years ago women should have been told to regard their husbands as if they had absolute power and were due complete respect. It should be noted that I am not arguing against the position of Saint Paul; I am simply stating it and using it as an example of a social custom which, for better or for worse, has begun to lose its compulsory force. It would be difficult, if possible, to reverse the course of history and revoke legislation which has liberated women even if the plea were made that such legislation runs counter to the Law of God as revealed to the Apostle.

In this connection it should be pointed out that regardless of our respect for women and of our presumed belief in their equal rights to life, liberty, and the pursuit of happiness, we still trace descent through the male line. We bear our fathers', not our mothers', names. We boast about our male ancestors of the distant past, not about our female. And even in so enlightened a country as the United Kingdom, a queen is possible only if there is no male heir. These are things which people accept without much dispute or argument. They belong to tradition and are no more explained on principles of utility than the rules of grammar. Yet should the occasion arise, even they might be questioned. If it is asked what such occasions might be, the reply would be a pointing of the finger to the new duties which have been imposed upon women, such as service in the Army and Navy, and new rights, such as equal economic opportunity.

Though we know next to nothing about the origin of our most ancient and honored traditions, we do know something about how they are changed. We know how women got the vote, how they got the right to own property, how they got an education in higher institutions of learning, and how they entered almost all of the professions: law, medicine, engineering, and so on. And that way was through the initiative of individuals. The franchise was given to women not because that mythological being known as *Society* decided to give it to them, but because Susan B. Anthony and her associates fought for it, made themselves conspicuous, wrote, spoke, incurred ridicule and abuse, argued, expounded, went to jail, and generally forced Society to give them what they wanted. Yet even today they are protected by special legislation in some quarters, legislation which some of them want to see annulled, as if they were still considered to be a special class of human beings. Why then do individuals protest against the social pattern? Well, why do individuals try to change their habits when they are convinced that their habits are bad?

Suppose for the sake of simplicity we divide up human interests into the traditional classes of thinking, feeling, and willing, corresponding to the equally traditional values of truth, beauty, and goodness. This is obviously both incomplete and very rough. The classes overlap and are not clearly defined. Nevertheless they will serve our purpose. We posses by inheritance certain approved ways of discovering the true, creating the beautiful, doing the good. We come into possession of these ways at an early age, through the influence of what may be broadly called education: education at home, in school, and in our social contacts. We learn something of rudimentary logic when we are caught in lies and try to wriggle out of them; when we do arithmetic in the early grades; when we relate our experiences to others. Consistency becomes almost second nature, at least when we are dealing with others. We demand it of them and they demand it of us. As we grow up we learn something of science and the experimental method. We begin to use such terms as "on the whole," "for the most part," "average" weights and measures. We read articles and letters and maybe even write them which we hope will be logical. We begin to distinguish between premises and conclusions. We accept certain rules of evidence, not necessarily those of the courts but those of the laboratory and study. Then we come up against a case where the usual rules do not apply.

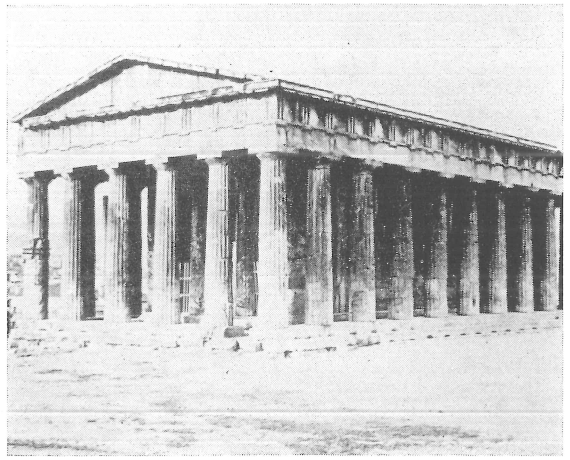
For instance, it was long believed that there was no way of handling logically problems involving infinitesimals and infinite magitudes. Change and rates of change seemed illogical and absurd. Then Newton and Leibniz discovered the calculus. Again, in the early nineteenth century living matter was believed to be absolutely different from non-living. It was maintained by tradition that no organic substance could be produced out of inorganic materials. So long as the great mass of scientists held to that belief, no attempt would be made to weaken it. But an individual began to doubt it and in 1828 urea was synthesized in a laboratory. Until the third quarter of the century it was believed that rotten flesh could give rise to little organisms—worms—and that, as in folklore eels were born out of the horse-hairs in watering troughs, so water itself if allowed to stand would in time produce spontaneously tiny wriggling creatures which were probably the larvæ of mosquitoes. But again a man arose, Pasteur, who doubted this theory. His long dispute with Bastian shows to what lengths he was willing to go to prove what later was called the Law of Biogenesis. These and similar events modified what we believed to be true and also modified profoundly our ways of reaching the truth. Now every high school student has better training in the experimental method than eminent scientists of two hundred years ago. The traditional ways of reaching truth

were modified by the action of individuals who refused to accept them without question.

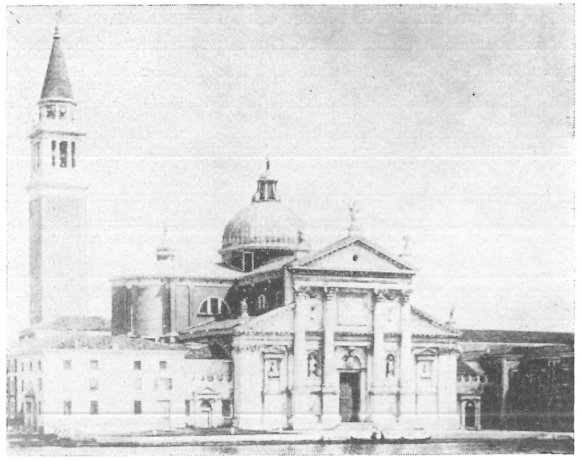
One of the greatest changes which was introduced into western standards of goodness was brought about by Christianity. I refer to the acceptance of charity, in the Greek sense of brotherly love. It is safe to say that only in some of the Stoics was there any general acceptance of charity in the pagan world. It is true that even after two thousand years of Christianity we still do not practice brotherly love on all occasions, to all people, but we would be ashamed to admit it. In America the most devious politicians feel the necessity of basing their programs on this foundation, though in reality they may be simply furthering their own ends. One cannot argue that charity is more needed nowadays than it ever was. It has always been needed and if the ancient Greeks had had a bit more of it, their city-states would have had a longer and more secure life. But its spread even to those regions where it is accepted with a kind of revolting hypocrisy was made possible through the work of individual human beings devoted to its propagation. Saints, martyrs, missionaries, priests, worked for it and worked for it against the powerful union of warriors, slave-holders, and later, industrialists. There are still people of course and people in positions of power who refuse to think of their enemies as brothers, or even of the poor and unfortunate as brothers, and there are some who do not consider their brothers as brothers. "Each man for himself and the Devil take the hindmost," may still be the motto of large numbers of our fellowmen. But it is a motto usually spoken only in clubs and smoking cars. And often these very men are the first to contribute a large check to the Community Chest, if only for the wrong reasons.

The history of art shows precisely the same thing. Works of art have changed, as artistry has changed, through the efforts of individual artists, not through the action of society. We have the following sets of innovation in the history of architecture: Greek, Roman, Romanesque, Gothic, Baroque, a period of revivals—gothic, classical, etc., etc.,—and finally what is called modern. We do not know any longer who introduced the Roman arch into architecture nor who introduced Romanesque churches, though we do know something about when they were introduced. Gothic still remains something of a mystery too, though we have more information about that. But when we come to the Italian Renaissance we have the records of individual architects, as we do for the various revivals and for modern. In almost all cases we can reconstruct the arguments used to modify tradition, some of them sound, some of them sentimental and unsound. And we know that just as styles in painting changed due to the influence of people—not society—so did writing and sculpture.

As I write this I look out of my window and see one end of the facade of a building which is almost a complete history of architectural forms. Round part of the roof runs a balustrade, though the roof is not flat and there is no danger of anyone falling off of



Theseon—Athens



San Giorgio Maggiore—Venice

it. The balustrade is surmounted by two funerary urns, which contain no ashes for they are not hollow. Below these urns runs a decorative panel in which is the skull of an ox in stone with stone swags pinned to its horns in the middle and presumably to the panel on the ends. Below this panel is a flat cornice, below which in turn are the windows. Four pilasters with Corinthian capitals between them and on the ends are appliquéd to the wall. They support nothing. Above one of the windows is a simple pediment of the kind one sees on wooden roofs and Greek temples and each of the windows, though not set in an arch, is surmounted by a keystone. Here we have an example of the preservation of forms as decoration which once served a useful purpose. There is no detail in this scheme, including the skull, which cannot be explained as once having had a purpose. But that purpose is now obsolete and we see instruments turning into *objects d'art* for the very reason that they are obsolete. The most amusing example as well as the most obvious is the use of the pediment as ornament.

The pediment is a cross-section of a building with a hipped roof. It is thus a functional element in a certain type of building. The balustrade is a protection for the edge of a high platform. Funerary urns were used to contain the ashes of the dead. Pilasters originally were what showed of encysted pillars. Keystones were the central elements in arches against which the other stones pushed. Even the skulls were once hung about temples as the residues of sacrifices. Since it would take too long to detail the history of the emergence of all of these details into decorative motifs, we may as well confine ourselves to one, the pediment. In the Doric temple we see the remains of a wooden building not only in the hipped roof but also possibly in the triglyphs and metopes. Without

Church of St. Cecilia—Rome—Ed. Alinari

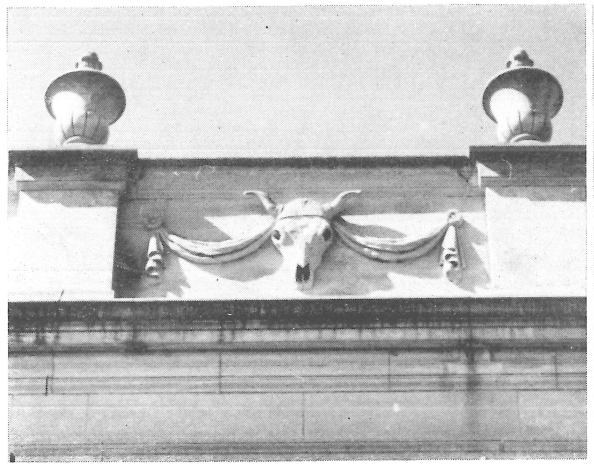
"The pediment . . . . lifted off of buildings and used to surmount . . . . even highboys . . . . and finally . . . . a clock."

Mantel Clock
Chippendale Highboy
Courtesy of The Metropolitan Museun. of Art

pressing the point, one could argue that a Doric temple is a wooden building built of stone. The form of the wooden construction has been already frozen and preserved as the "right" kind of construction.[1] When the Hellenic-Roman style became revived in the Renaissance, we see the pediment appearing again as in the church of San Giorgio in Venice, where again it serves as ornament. To quote Ruskin, not knowing what else to do with it, the architect punched a hole in it. The next step in its evolution was to break the pediment at its apex, preserving the hole, thus producing the famous broken pediment. From then on sculpture or other adornment could be put in the hole, the horns of the break could be curved inwards or outwards, the pediment could be lifted off of buildings and used to surmount fireplaces, doorways, and even high-boys, and finally it appears without base as the frame of a clock. But such a history is in no way different from what happened to crenellations, gargoyles, or buttresses. The instrument turns into the *objet d'art* when it loses its utility.

But this is also the history of our standards of all artistic form, of social etiquette, of "poetic diction," of ceremonious speech, and of many social institutions such as the English nobility. One could lay it down as a principle that the loss of utility is the acquisition of dignity and that when something is no longer able to be justified on the basis of its use, it becomes inherently good. Paradoxical as this may seem, it is the one explanation which seems to fit the facts. In David Riesman's *The Lonely Crowd* we find that survivors of antiquated social groups become inner-directed. They uphold tradition, the ways of our fathers, the good old times. They are the bulwarks of stability in society and their existance can be justified on the ground that society without tradition would fall to pieces. So in the history of the arts, the inner-directed artist re-learns the lessons of the past and thus provides that element of immutability which gives historians of art some right to speak of unchanging values and forms. We happen to know, if we know more than one period of art, that even when painters retain the same subject-matters, such as the Crucifixion, each successive generation introduces changes in the manner of interpreting this central fact in Christian doctrine. But nevertheless it must be admitted that each successive generation also contains people who do not accept the new interpretation and follow the old pattern. There are still poets writing sonnets in the manner of Shakespeare and painters who paint in the manner of Raphael, just as all through the eighteenth and nineteenth centuries there were architects who built Gothic churches. One can thus write history in at least two ways: (1) by pointing out the continuity of forms, (2) by pointing out formal innovations. The third way, that of showing the interplay between tradition and innovation, which would be closer to the facts, is seldom if ever practised.

[1] For analogous remarks on Egyptian buildings, see Baldwin Smith's comments in *Egyptian Architecture as Cultural Expression.*



On Skull and Urns—Sam Rosenberg

Signboard—Tunney Lee

The petrification of forms, whether of artistry, morals, politics, social organization, or what not, is presumably a constant element of cultural history. The time comes when an ancient form is so transformed that it ceases to be recognized. It is at least doubtful whether anyone who designed the elaborate Chippendale high-boys saw that he was taking over the broken pediments of Renaissance churches, as it is doubtful whether a man who puts an ox skull on a building as a decoration thinks that he is utilizing an ancient sacrificial custom analagous to hanging the scalps of one's enemies outside a hut. Such details have become sanctified by custom and are no more to be rationalized than opening letters with the adjective "dear." But at the same time it behooves everyone interested in understanding the course of artistry to observe the petrification of forms lest he be misled into believing that he is observing eternal laws of æsthetics. What is eternal, in the sense of being lasting, is the interplay between innovation and tradition. What comes out of this conflict is always something partly new and partly old. That is very hard for one who believes in historical simplicity to swallow, but all facts are hard to swallow. Historians would prefer to plot a curve with no depressions or sudden elevations. But such things seem to be more characteristic of the world of our desires than of that of observation.

visitors to the school of design for the fall semester:

J. C. PRITCHARD: *(October 4, 5, 6) Director and secretary of the furniture Development Council, London, England. Visiting lecturer discussing methods and processes used in design and manufacture in England.*

ROBERT B. NEWMAN: *(October 11, 12, 13) Acoustical Consultant and member of the faculty of Massachusetts Institute of Technology conducting seminars with students.*

LAWRENCE HALPRIN: *(Month of October) Landscape architect from San Francisco, California, and teacher in the Department of Landscape Architecture, University of California conducting problems with students in Landscape Architecture.*

BRIAN HACKETT: *(Month of February) Senior Lecturer in Landscape Architecture and lecturer on town planning at the University of Durham, England, acting as visiting critic on special landscape problem.*

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