BUGULMA, a town of European Russia, in the government of Samara, 243 miles from the city of that name, on the small river Bugulminka, a sub-tributary of the Volga, in 54° 32′ N. lat. and 52° 47′ E. long. The town rose into existence about 1741–5, and was peopled by soldiers, exiles, and peasants. During the Pugacheff insurrection it was vainly besieged by the rebels. In 1781 it was made a town of the Ufa government; in 1806 it was transferred to Orenburg, and in 1851 to Samara. Its principal importance is derived from its situation at the junction of two great roads from Ufa and Orenburg, by which it maintains an extensive transit trade. A great annual fair is held from 14th to 21st of September (o. s.). Population in 1867, 5455.

BUGURUSLAN, a town of European Russia in the government of Samara, situated at the junction of the rivers Kinell and Tarkhanka, 177 miles E.N.E. of Samara, in 53° 39′ N. lat. and 52° 25′ E. long. It dates from about 1748, and in the time of the Pugacheff revolt was the scene of the outrages of Karpoff's band. Its changes from government to government coincide with those of Bugulma. The principal buildings are two or three churches, a monastery, a hospital, and a caravanserai. It manufactures leather, wax, potash, and beer, and carries on a pretty extensive trade. There are two annual fairs. Population in 1867, 7450.

BUHLE, Johann Gottlieb (1763–1821), distinguished as a scholar and an historian of philosophy, was born at Brunswick, and graduated at the university of Göttingen, where he obtained a chair at a very early age. Thence he was called to the professorship of ancient languages at Moscow. After his return to Brunswick he was appointed to the chair of natural law, which he held till his death in 1821. Buhle's activity was great, and the productions of his pen are numerous. He edited *Aratus* and part of *Aristotle* (the Bipontine edition, 5 vols.), the first volume of which is a masterly survey of Aristotelian literature. His fame, however, is principally derived from his labours on the history of philosophy. The *Geschichte der philos. Vernunft*, 1793, was suspended after the first volume, but the *Handbuch der Geschichte der Philosophie*, 8 vols. 1796–1804, is a very complete and valuable work. More important than either of these is the *Geschichte der neuern Philosophie*, forming one of the great series of histories of the sciences from the Renaissance. It is a work of much learning, and is well written; its faults are general weakness in critical appreciation and want of due sense of proportion. The *History of Modern Philosophy* has been translated into French, 6 vols. 1806.

BUHL-WORK, otherwise Bool, Boule, or Boulle-work, is a kind of inlaying and ornamentation of cabinet-work, so named after the inventor André Charles Boule, a celebrated French cabinetmaker (1642–1732) By a happy selection of different woods from India and Brazil, arranged with great taste, and the use of brass, ivory, gold, tortoise-shell, &c., Boule produced upon his furniture arabesques and pictures, representing a variety of animals, flowers, and fruits; and he finally succeeded in producing historical scenes, as battles and hunts, landscapes, and other artistic effects. Louis XIV. appreciated his abilities, gave him lodgings in the Louvre, and, in 1672, appointed him engraver in ordinary of the royal seals. In the patent authorizing this he received also the designations of "architect, painter, carver in mosaic, artist in cabinet-work, chaser, inlayer, and designer of figures." His skill was great in all these branches, and he carried them to a high degree of artistic perfection in timepieces, screens, furniture, and other articles. He worked for the royal residences and for foreign princes, and attained fortune and position.

The beginnings of art in carving are found amongst the relics of prehistoric races, and when it arrived at the degree of perfection it afterwards attained in the East, inlaying was a natural result. We find this to have been practised by the ancient Egyptain and other Asiatic races. Its attendant, veneering, was also employed by them, workmen applying the veneer with glue being represented on the Egyptian monuments. As civilization advanced westward, the Greeks and Romans followed in the art, the latter race inlaying their furniture with marquetry or tarsia-work, using ivory, ebony, box, palm, bird's-eye maple, beech, and other woods. Their bronze articles they damascened with ornaments of the precious metals and metallic amalgams. The spirit of the Middle Ages was adverse to the development of this art, and but few traces of it are found. In the South Kensington Museum is a coffer of cypress, with flat surface imagery filled in with coloured wax composition, that dates from the 14th century. The Venetians derived their marquetry from Persia and India, as is indicated by the geometric patterns inlaid with ivory, metal, and woods, stained of various colours. Florence took a prominent place in this manufacture in the 15th century. Certosina-work was the result; it was so called from the great Certosa, Charterhouse, or Carthusian monastery, between Milan and Pavia, in the choir-fittings of which this kind of ornament, ivory inlaid into solid cypress and walnut wood, is employed. Work in the Persian style, with its geometric figures, still reaches us from Bombay, the present great seat of the Parsees.

The Renaissance artists chiefly employed wood in making furniture, ornamenting it with gilding and painting, and inlaying it with agate, carnelian, lapis-lazuli, marble of various tints, ivory, tortoise-shell, mother-of-pearl, and various woods. Boule improved upon this by inlaying brass devices into wood or tortoise-shell, which last he greatly used according to the design he had immediately in view, whether flowers, scenes, scrolls, &c.; to these he sometimes added enamelled metal. In this process the brass is thin, and, like the ornamental wood or tortoise-shell, forms a veneer. In the first instance the production of his work was costly, owing to the quantity of valuable material that was cut away and wasted, and, in addition, the labour lost in separately cutting for each article or copy of a pattern. By a subsequent improvement Boule effected an economy by gluing together various sheets of material and sawing through the whole, so that an equal number of figures and matrices were produced at one operation. Boule adopted from time to time various plans for the improvement of his designs. He placed gold-leaf or other suitable material under the tortoise-shell to produce such effect as he required; he chased the brass-work with a graver for a like purpose, and, when the metal required to be fastened down with brass pins or nails, these were hammered flat and disguised by ornamental chasing. He also adopted, in relief or in the round, brass feet, brackets, edgings, and other ornaments of appropriate design, partly to protect the corners and edges of his work, and partly for decoration. He subsequently used other brass mountings, such as claw-feet to altars and pedestals, or figures in high or low relief, according to the effect he desired to produce. Boule's contemporary, Reisner, a German, used a variety of woods, tulip-wood more especially, in the production of flowers and other ornamental designs, contrasting the dark with the light kinds, crossing the grain, and employing other ingenious devices. After him this particular style was called Reisner-work. The Spaniards of the 16th century used silver for inlaying.

See *Grande Dictionnaire Universel du XIXe siècle;* Pierer's *Universal-Lexikon*, Altenberg, 1868; *Encyclopédie des Gens du Monde;* Bemrose's *Buhl-work and Marquetry*, a very useful manual; Pollen's *Furniture and Wood-work.*

BUILDING

Relation of building to architecture.

THE art of building comprises the practice of civil architecture, or the mechanical operations necessary to carry the designs of the architect into effect. It is not unfrequently called *practical architecture;* but the adoption of this term would tend only to confuse, by rendering it difficult to make the distinction generally understood between architecture as a fine or liberal art and architecture as a mechanical art. The execution of works of architecture necessarily includes building, but building is frequently employed when the result is not architectural; a man may be a competent builder without being an architect, but no one can be an accomplished architect unless he be competent to specify and direct all the operations of building. A scientific knowledge of the principles of masonry, carpentry, joinery, &c., and of the qualities, strength, and resistance of materials, though of the utmost importance to an architect, must be attended by a minute acquaintance with a great variety of less ambitious details. Such are those which relate to the arrangement of a plan for the greatest possible degree of convenience on the smallest space, and at the least expense; its transference to the ground; the preparation and formation of foundations; the arrangement and construction of drains, sewers, and vent-shafts; the varieties of walling with stone, and of laying bricks in brickwork; the merit of the various modes of bonding and tying walls, both lengthwise and across; the arrangement of gutters on roofs, to get sufficient fall, and to conduct the water to the least inconvenient places for fixing trunks to lead it down; the arrangement and formation of flues; the protection of walls from damp, of timber from moisture and stagnant air, and of metals generally from exciting causes; the cost of materials and labour, and the quantity of each required to produce certain results. Together with these, an architect ought to be practically acquainted with all the modes of operation in all the trades or arts employed in building, and to be able minutely to estimate beforehand the absolute cost involved in the execution of a proposed structure. The power to do the latter necessarily involves that of measuring work, and ascertaining the quantities done. These things may certainly be referred to the surveyor or measurer, but they are not the less incumbent on the architect, who cannot be said to be thoroughly master of building, or the practice of his profession, unless he be skilled in these operations.

Building includes what is called construction, which is the branch of the science of architecture relating to the practical execution of the works required to produce any structure; it will therefore be necessary to explain the subject in a general manner before entering upon building in detail.

It may, perhaps, be useful to premise that, should it occur to some readers that the present article has too great a tendency to supply information on the manner of building in a modern style, and that the earlier method is not elaborated, it must be remembered that, although the styles of architecture have varied at different periods, buildings, wherever similar materials are employed, must be constructed on much the same principles. Greater scientific knowledge of the natures and properties of materials has, however, given to the modern workman immense advantages over his mediæval brother craftsman, and caused many changes in the details of the trade, or art of building, although stones, bricks, mortar, &c., then as now, formed the element of the more solid parts of all edifices. The introduction of fir, too, in place of the more solid and durable timber oak, has likewise occasioned similar changes, too numerous to mention in detail, in the sister arts of carpentry and joinery, probably also causing the division of the carpenter's trade of the mediæval period. Certain exceptional features of mediæval work did exist, and most, if not all, will, it is hoped, be found referred to in this article.

General Principles of Construction.

The object of construction is to adapt and combine fit materials in such a manner that they shall retain in use the forms and dispositions assigned to them. If an upright wall be properly constructed upon a sufficient foundation, the combined mass will retain its position, and bear pressure acting in the direction of gravity, to any extent that the ground on which it stands and the component materials of the wall can sustain. But pressure acting laterally has a necessary tendency to overturn a wall, and therefore it will be the aim of the constructor to compel, as far as possible, all forces that can act upon an upright wall to act in the direction of gravity, or else to give it permanent means of resistance in the direction opposite to that in which a disturbing force may act.

Arch.

Thus when an arch is built to bear against an upright wall, a buttress or other counterfort is applied in a direction opposed to the pressure of the arch.

Roof.

In like manner the inclined roof of a building, spanning from wall to wall, tends to thrust out the walls; and hence a tie is applied to hold the opposite sides of the roof together at its base, where alone a tie can be fully efficient, and thus the roof is made to act upon the walls wholly in the direction of gravity; or where an efficient tie is inapplicable, buttresses or counterforts are added to the walls, to enable them to resist the pressure outwards.

Beam.

A beam laid horizontally from wall to wall, as a girder to carry a floor and its load, may sag or bend downwards, and tend thereby to force out the walls; or the beam itself may break. Both these contingencies are obviated by trussing; which renders the beam stiff enough to place its load on the walls in the direction of gravity, and strong enough to carry it safely. Or if the beam be rigid in its nature, or uncertain in its structure, or both (as cast-iron is), and will break without bending, the constructor, by the smith's art, will supply a check and ensure it against the possible contingency.

Perfect stability, however, is not to be attained with materials which are subject to influences beyond the control of man, and all matter is subject to certain influences of that nature. The influences mostly to be contended against are heat and humidity, the former of which produces movement of some kind or to some extent in all bodies; the latter, movement in many kinds of matter; whilst the two acting together contribute to the disintegration or decay of materials available for the purposes of construction. These pervading influences the constructor seeks to counteract, by the selection and disposition of his materials accordingly. From the tenacity of wrought iron, and its almost plastic character in the hands of the smith, it is employed to tie together other more bulky but less costly and more rigid materials; but on account of its exceeding susceptibility of heat, and its consequent expansion and contraction, wrought iron must be used in short lengths only, unless where protected from great alternations of heat and cold. The rapid decay, too, of wrought iron when exposed to humidity, and especially when it is alternately wet and dry will teach the constructor not to expect enduring stability in his works if he makes them dependent upon wrought iron. Cast-iron is brittle, and may not be exposed with impunity to transverse strain, especially if such strain be attended by action tending to induce vibration; it expands and contracts under the influence of heat, but it resists compression in every direction, and if used in small bodies, is valuable as a means of connecting other materials. Timber, being practically unchangeable in the direction of its length from the mere absorption of either heat or humidity, and at the same time practically both inextensible and incompressible in that direction, and being also readily wrought and easily combined alike with other timber and with iron, is a valuable material in the hands of the constructor; but it shrinks and swells in the direction of its thickness, and, in consequence, is subject to rapid decay when exposed to alternations of moisture and dryness; and although in many varieties timber is perdurable and unchangeable in form if it be kept either altogether free from moisture or always wholly wet, its quality of inextensibility is greatly diminished in value to the constructor on account of the comparatively slight resistance it offers to compressing power, and the comparative ease with which its fibrous structure is torn asunder. From this cause it cannot be grasped or otherwise held so that its power of resisting extension may be made available in any degree proportioned to its strength; whilst its quality of incompressibility in the opposite direction is of less value to the constructor for many purposes which require that quality in the material, because it absorbs moisture by the ends of the fibre more readily, and with a far more mischievous effect, than it does in the direction in which it is compressible. Hence timber rots more rapidly by the ends than by the sides.

Stone and brick, the other main available materials in general construction, keep their places in combination by means of gravity. They may be merely packed together, but in general they are compacted by means of mortar or cement, so that although the main constituent materials are wholly incompressible, masses of either or of both combined in structures are compressible until the setting medium has indurated to a like condition of hardness. That kind of stone is best fitted for the purposes of general construction which is least absorbent of moisture, and at the same time free to work. Absorbent stone exposed to the weather rapidly disintegrates; and for the most part non-absorbent stone is so hard that it cannot always be used with a due regard to economy. When, therefore, fitting stone of both qualities can be obtained, the harder stone can be exposed to the weather, or to the action which the softer stone cannot resist, and forms the main body of the structure of the latter so protected. The hard and the soft should be made to bear alike, and should therefore be coursed and bonded together by the mason's art, whether the work be of stone wrought into blocks and gauged to thickness, or of rough dressed or otherwise unshaped rubble compacted with mortar.

Good bricks are less absorbent of moisture than any stone of the same degree of hardness, and are better non-conductors of heat than stone. As the basis of a stable structure, brickwork is more to be relied upon than stone in the form of rubble, when the constituents bear the relation to one another last above referred to, the setting material being the same in both; because the brick, by its shaped form, seats itself truly, and produces by bonding a more perfectly combined mass; whilst the imperfectly shaped and variously sized stone as dressed rubble can neither bed nor bond truly,—the inequalities of the form having to be compensated for with mortar, and the irregularity of size of the main constituent accounted for by the introduction of larger and smaller stones. The most perfect stability is to be obtained, nevertheless, from truly wrought and accurately seated and bonded blocks of stone, mortar being used to no greater extent than may be necessary to exclude wind or water, to prevent the disintegrating action of both upon even the most durable stone. When water alone is to be dealt with, and especially when it is liable to act with force, mortar is necessary for securing to every block in the structure its own full weight and the aid of every other collateral and super-imposed stone in order to resist the loosening effect which water in powerful action is sure to produce.

In the application of construction to any particular object, the nature of the object will greatly affect the character of the constructions and the materials of which they are to be formed.

Every piece of construction should be complete in itself, and independent as such of everything beyond it. A door or a gate serves its purpose by an application wholly foreign to itself; but it is a good and effective or a bad and ineffective piece of construction, independently of the posts to which it may be hung. Whilst the wheel of a wheel-barrow, comprising fellies, spokes, and axle-tree, is a piece of construction complete in itself, and independent as such of everything beyond it, an arch of masonry, however large it may be, is not necessarily a piece of construction complete in itself,—it would fall to pieces without abutments.

Bridge. Thus, a bridge consisting of a series of arches, however extensive, may be but one piece of construction, no arch being complete in itself without the collateral arches in the series to serve as its abutments, and the whole series being dependent thereby upon the ultimate abutments of the bridge, without which the structure would not stand. This illustration is not intended to apply to the widely distended masses of the older bridges, by which each pier becomes sufficient to abut the arches springing from it, but which tend, in providing for a way over a river, to choke up the way by the river itself, or compel the river to throw it down, or otherwise destroy its own banks. A bridge, of which the way is formed upon arches of masonry, may be thus but one piece of construction; and in like manner,

Pointed church or cathedral. that paragon of constructive skill, the complete church, whether cathedral or otherwise, as built in the Pointed style when that style was practised in full accordance with true constructive principles, is but one piece of construction. As in the long series of arches in a bridge, viaduct, or other such work, in which the piers are vertical supports to the bridging structure, and may be of no greater substance than is necessary to bear the weight coming directly by vertical pressure from the superincumbent structure and its possible load, but throwing all the pressure arising from weight acting laterally, or as thrust, upon terminal abutments,—nothing may be omitted, as nothing can be removed from the structure of the Pointed arch cathedral, or other church built in that style, the whole system of which is bridge-like in construction, without leaving something unsupported or unresisted that requires vertical support or lateral resistance. The western towers of a Pointed cathedral form effective abutments to the long series of arches of the inner ranges over the piers which stand between the nave and the aisles on both sides, whilst turrets or massive buttresses and deep porches upon the northern and southern transept fronts perform the same services in respect of the arches of the transepts. The counteracting east end of the chancel forms a true constructive abutment to the arches of the chancel, whilst the tower, with, it may be, a spire upon it, at the intersection of the four grand compartments of the cross, gives, by its weight, abuttal to them all. The want of this last-named grand and essential body in the system is but too strongly marked in many of the English cathedrals, by the iron bars which have been applied to tie in the arches of the nave

transepts, and chancel, and to relieve the piers upon which the transept arches bear at a higher level from the thrust to which, being without the weight of a tower upon them, they have continually yielded. Transversely the weight and the thrust of the vaulted ceilings of the nave are brought up to, and thrown against, the piers of the clere-story, which stand upon the main piers or columns of the interior below, and are abutted by flying buttresses, which carry the thrust down to the pinnacle-weighted buttresses of the outer aisle walls, which have already received the weight and thrust of the vaulted ceilings of the aisles themselves. Corbels in the walls and spreading capitals upon shafts take the weight directly, and leave the walls and piers but little encumbered in the middle, so that the vertical structure is continued upwards without bearing upon the springing stones of the arches.

But it is not necessary that the arch employed should be the Pointed arch, to produce combinations as effective in construction as the most perfectly designed and extensively elaborated work of the kind referred to as models of constructive skill; the skill consists in a full and clear perception of the bearing and leaning of every part, and of the means necessary to support and counteract the bearings and the leanings within the reasonable limits of the work with reference to its object and purpose—to the end that the work may become complete in itself, and independent as a piece of construction of everything beyond it.

In making reference to the noble works of construction above referred to, in which the art of the mason is mainly employed, as works exhibiting construction most fully and most truly, the hall must not be passed over without remark, and of all the great halls of the class to which Westminster Hall belongs, it is itself the most effective as a work of construction; and its effect is wholly produced by the magnificent roof which covers it. This roof is a piece of carpentry admirably designed to resolve it into a compact body to act upon the walls in the direction of gravity alone. But the designer may not have felt quite certain of the results, so whilst erecting massive walls on which to place his elaborate combination of timber, he threw up against the lateral walls a series of flying buttresses to check any tendency of the roof to spread under its own weight in the absence of a thorough transverse tie; for these buttresses are said to be independent of the walls, not being built into them.

An application of the principles of construction exhibited in the most perfect works of constructive skill ever executed, as above indicated, may be made in the rougher operations

Cuttings. of mere practical utility. The sides of cuttings through certain earths in the formation of lines of inland communication, whether carriage roads, railways, or canals, are sometimes required to be widened out to an inordinate extent because of the looseness or slipperiness of the soil, or must otherwise be retained or held upright by special constructions. The expense of the first formation of a cutting under given circumstances is easily calculable, and so is the time within which the work may be effected. Experience has proved that there is for every soil a limit in depth beyond which it becomes more expedient to drift the required way, and construct a vaulted tunnel of sufficient dimensions, than to make an open cutting with the requisite slopes. Even when the first cost would not decide the question, the preference is nevertheless often given to the tunnel because of the greater security of constructed work.

Before proceeding to the consideration of the means of enabling opposite retaining walls to assist each other, it may be worth while to consider, whether retaining walls are generally constructed so as best to adapt their components to the duty to be performed. No one would place a buttress intended to resist the thrust of an arch within the springing walls, or under the arch whose thrust is to be resisted; yet in the construction of retaining walls, according to the common practice, the counterfort is placed on that side which receives the pressure, where its utility is very questionable, except to keep the retaining wall from falling back against its load, which, from the transverse section generally given to such walls, they would be apt to do, if not so propped up by their counterforts. Wharf and quay walls, and the revetment walls of military works, may require a face unbroken by projections; but this is not the case with retaining walls for roads and railways, where a long line of projecting buttresses would be unobjectionable, the counterforts becoming buttresses and merely changing places with the wall. On account of the common practice of battering the faces of retaining walls in curved lines, and of radiating the beds of the brickwork composing them from the centre of curvature in every part, the back of the wall must contain more setting material than the face, with the same quantity of solid brick, that is, if the work be bonded through. Counterforts must be built in the same courses, and consequently must have still thicker beds of compressible mortar than the wall; or the bond between the wall and its counterfort must be dropped, and the counterfort thus become utterly inefficient.

Examples at Camden Town. The retaining walls in the cutting upon the line of the extension of the London and North-Western Railway, from Camden Town to Euston Square, are, according to the common practice, built wholly of brickwork in radiating courses and with counterforts following their own contour. In this case the centre of gravity of the wall falls wholly

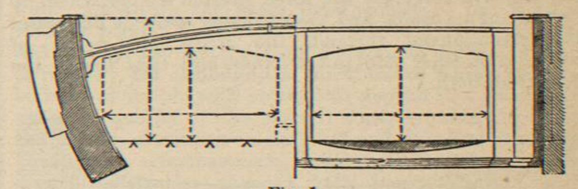

Fig. 1.

Transverse section of the Euston Incline retaining walls, one-half as executed with cast-iron struts to counterforted and reclining walls, and the other half with the brick-built abutting beam to counter-arched retaining walls strutted at the toes of the springing walls by inverted arches.

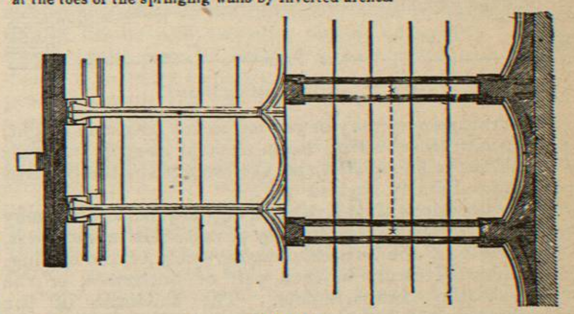

Fig. 2.

Plan of the above showing the part as executed above the iron struts, with the rails passing underneath, and the other part at the level of the rails, with the inverts in plan under them.

behind its base, and the counterforts not commencing until the wall has reached one-third its height render it still more dependent for support upon the ground it is intended to retain. It is well known that these extensive walls, though furnished with all the collateral works necessary to protect them from exposure to undue influences, and although set nearly one-fourth of their height in the ground, failed to a considerable extent. A system of strutting with cast-iron beams, across from the opposite walls, as shown in