МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ
РОССИЙСКОЙ ФЕДЕРАЦИИ

Федеральное государственное бюджетное образовательное учреждение
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"Пензенский государственный университет
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(ПГУАС)

АНГЛИЙСКИЙ ЯЗЫК ДЛЯ БУДУЩИХ АРХИТЕКТОРОВ И СТРОИТЕЛЕЙ

Рекомендовано Редсоветом университета
в качестве учебного пособия для студентов,
обучающихся по направлениям подготовки
08.03.01, 08.04.01 «Строительство»,
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Содержит материал по темам, изучаемым в строительном ВУЗе, а также тексты, рассказывающие о новых строительных материалах. В учебном пособие представлены упражнения, позволяющие понимать тексты и задания к ним. Пособие хорошо иллюстрировано.

Подготовлено на кафедре иностранных языков и предназначено для студентов, обучающихся по направлениям подготовки 08.03.01, 08.04.01 «Строительство», 07.03.01, 07.04.01 «Архитектура».

ПРЕДИСЛОВИЕ

Учебное пособие содержит материал по темам: Строительные материалы, Камни и их классификация, Виды цемента, Бетон, Искусственный камень, Древесина, Стекло, Краски и многие другие.

Пособие состоит из трех частей и нескольких разделов, в которых представлены тематические материалы по строительству на современном английском языке. В пособии также представлены задания, на основе выполнения которых проверяются знания изучаемого материала и практикуется его использование в речи на английском языке.

Тексты сопровождаются англо-русским вокабуляром, облегчающим понимание текста и иллюстрациями. Каждый текст заканчивается контрольными вопросами для проверки понимания текста.

Трудности понимания предлагаемого материала снимаются благодаря использованию авторами тематических глоссариев, представленных на английском и русском языках.

Материал, представленный в данном учебном пособии, является базовым и необходимым для формирования навыков понимания текстов на английском языке. Пособие поможет студентам научиться читать и понимать аутентичные тексты, выполнять их адекватный перевод, вести беседы по изучаемой теме.

Пособие подготовлено на кафедре иностранных языков и предназначено для бакалавров, магистрантов и аспирантов, изучающих английский язык в неязыковом вузе.

Учебное пособие может быть использовано студентами и обучающимся по всем специальностям неязыкового вуза.

PART I. TEXTS FOR COMPREHENSIVE STUDY

BUILDING MATERIALS - THEIR NATURE, PROPERTIES AND MANUFACTURE

Text 1. Stones: practical classification and general distinctions

1. Read the following words and word combinations. Find the sentences with these words and word combinations in the text and translate them into Russian.

magnesia – магнезия, окись магния
to quarry – добывать
feldspar – полевой шпат
hornblende – амфибол
mica – слюда
potash – поташ
to solidify – твердеть, застывать
manganese – марганец
tough – жесткий, упругий
igneous rocks – горные породы вулканического происхождения
argillaceous – глинистый
shale – сланец
conveyed to the sea – переправленный в море
lateral – горизонтальный, боковой, поперечный
cleavage – расщепление, раскалывание
thaw – оттепель; топить, растопить; таять, растаять, смягчаться
lichen – лишайник
superficially – поверхностно
lump sugar – кусковой сахар
to derive – извлекать
vein – вена, жила
to retain – удерживать, сохранять
to intermingle – смешивать(-ся)
to percolate – проникать, просачиваться
mottled surface –пятнистая поверхность
serpentine – змеевидный,извилистый, извивающийся
translucent – полупрозрачный, просвечивающийся
onyx – оникс
stalagmite – сталагмит
divergence – расхождение, отклонение
sedimentary – осадочный

fossil – ископаемый, окаменелый
to traverse –пересекать
vertical percolation – вертикальное проникновение
fissure – трещина, расщелина
dolomite – доломит; the Dolomites - Доломитовые Альпы
abundant – обильный
flint – кремень
shingle beaches – пляжи, покрытые галькой
insoluble – нерастворимый, неразрешимый
angularity – угловатость
rust – ржавчина

2. Read and translate the text.

The classification of stones as basalts, granite, slates, marbles, limestones, and sandstones. The term *basalt* is made to include all black, heavy or homogeneous. The true basalt is an Augitic stone, named after the mineral Augite or Pyroxene, of which, with Labradorite Felspar (a silicate of alumina and lime), it is composed. Augite having magnesia for its base, and being of a dark or black colour. There is much of it in the British Islands, but it is so difficult to quarry and hard to work that it is little used, save locally as road metal.

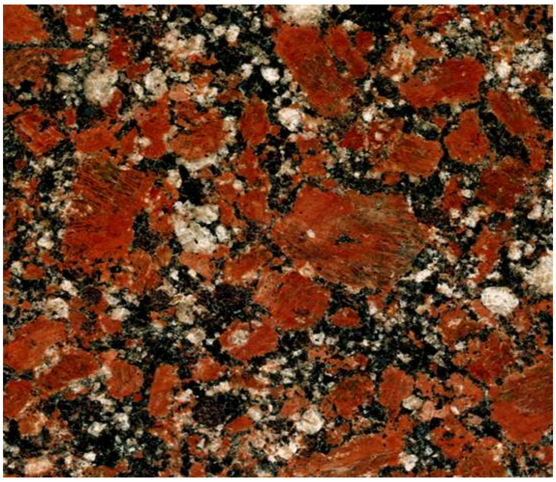
Granites comprise all stones of independent crystals of differing materials, which are so intimately connected as to form a homogeneous whole, and include most of the felspathic and hornblendic stones. All true granites contain felspar and quartz, and the ordinary typical granite consists of felspar, quartz, and mica, while many contain hornblende also. Of these constituents, the felspar is generally of that description known as Orthoclase, which is a silicate of alumina and potash, though the Labradorite felspar is also found. Felspar varies in colour, being sometimes white, sometimes grey, sometimes pink, and sometimes a deep rich red, and the colour of the granite, of which it forms a large part, varies accordingly.

The quartz crystals also vary in tint, though they are frequently white. They are almost pure oxide of silicon, otherwise known as silica; and it is found that they contain minute cells partly filled with water. The grains of felspar and mica are partly embedded in the quartz grains, and hence it is concluded that the quartz was the last to solidify. The mica occurs as small flakes of dark colour, which flash as they catch the light. It is a source of weakness, as it is liable to decay.

Hornblende, otherwise known as Amphibole, is a silicate of magnesia and lime, with iron and manganese. It is a very tough mineral, of a dark green or black colour, and frequently occurs in granites in small distinct crystals.

Granites which contain hornblende in place of or in addition to mica, are called Hornblendic or Syenitic granites, while other stones which contain felspar and hornblende alone, without either quartz or mica, are not granites at all, but Syenites, though in practice they are included among the granites. The crushing resistance of an ordinary granite varies from 5 to 12 tons per square inch, as tested on small cubes.

Under the term granite are commonly included other igneous rocks, little used for building purposes, such as the Porphyries, Elvan (of fine grain and free from mica), and Gneiss, which is constituted like granite, but has the mica more in layers, along which it splits easily, coming out in slabs from a few inches to a foot in thickness.

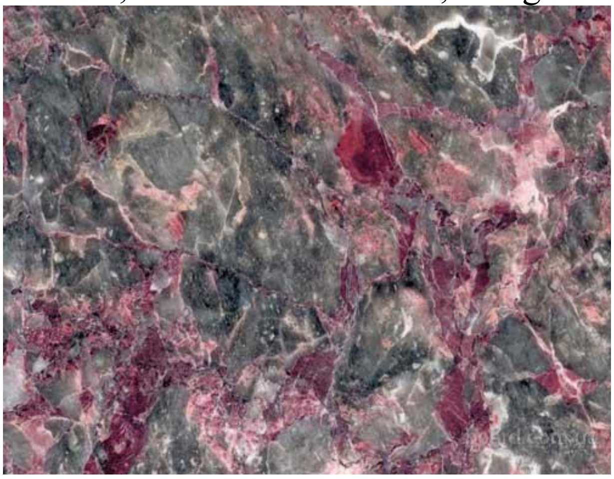


True *slates* are argillaceous in composition that is, they are composed of clay (silicate of alumina) and little else. The chemical elements of all clay, shales and slates are aluminium, silicon and oxygen, and the origin of all alike is to be found in the natural production of Kaolin, a pure white clay, by the decomposition of the felspar of felspathic rocks such as granites. This is washed into streams and rivers and so is conveyed to the sea, where, consisting of matter in an extremely fine state of division, it is carried further from the shore than the other ingredients of the original granite, and so is deposited separately, forming a clay bed. This forms material for newer clays, and so on; while clay beds which have long been subjected to vertical pressure have been compacted into shales and mudstones, and when these again are subjected to great lateral pressure and high temperatures they have been changed into the hard and strong material known as slate. Owing to the extremely high temperature at which the change takes place, slate, like all other metamorphic and igneous rocks, contains no organic remains. It is practically non-absorbent, and as it can be split into exceedingly thin parallel layers of considerable size, it is a most valuable roofing material. The crushing resistance of slate varies from 6 to as much as 14 tons per square inch, while its transverse strength is greater than that of any other stone.

Many other stones, both sandstones and limestones, which naturally occur in thin enough layers to be used for roofing purposes, are locally known as "slates", or sometimes as "slate-stones", or "tile-stones". These, however, split along their planes of bedding, and not along planes of metamorphic cleavage, and so are not true slates, having, in fact, each the characteristics of the class of stone to which it belongs.

Coly weston "slates", though used as roof coverings, are really limestone of a dark grey colour. The stone is obtained in the form of a block, or slate log, showing no sign of lamination. The logs are quarried in the summer and exposed to the weather through the winter, being watered daily except when hard frozen. If the winter be one of successive frosts and thaws, the block splits into thin slabs, while continuous frost with few alternations will produce thick slabs only, the splitting being done entirely by the weather, and the "slates" being ready for use when the spring arrives. All such, however, are more absorbent than true slates, and require strong roof timbers to carry them, while they foster lichen growth; but their colour is pleasing, and some architects use them to a considerable extent.

The term *marble* has come to include in practice not only marbles proper, but all limestones and even some other stones which are capable of being highly polished, and which then superficially look like marbles. True marbles are composed of practically pure carbonate of lime in a highly crystalline form, resembling lump sugar in structure. This resemblance is so strongly marked in the white that it has been given the name of "saccharine marble". The white marble has been metamorphosed from pure white limestones, while the coloured marbles derive their colour from impurities, mostly oxide of iron, in the original limestones from which they have been changed, the colour having run into beautiful veins and markings during metamorphosis. Almost all colours are represented, and all combinations of colour. The crushing resistance of marble is about equal to that of granite, while its weight varies little from i/olbs. per cubic foot. Like granite and slate it is also an excellent weathering stone, and can be obtained in large blocks; though it does not, as a rule, retain its polish for any length of time if exposed to the weather. The combination in the same stone of strength, size of block and beauty of colour and texture, renders marble one of the most valuable of building materials. These are metamorphic igneous rocks, produced by the alteration under heat of igneous rocks rich in olivine, which contains some 84%, of silicate of magnesia. This is frequently found intermingled with carbonate of lime formed by water percolation, and the result is a stone having a beautiful mottled surface. Though heavy and capable of carrying heavy loads, it is soft and easy to work, but it weathers badly, and so cannot be used externally with success. Lithologically, serpentines are Paleose stones, the mineral talc, which consists of silicate of magnesia and occurs in other forms as French chalk, steatite and asbestos, being its basis.



Alabasters are also commonly and wrongly classed among the marbles. The true Oriental Alabaster is a beautiful translucent and nearly white limestone, often now erroneously called onyx marble, whose circular markings indicate its stalagmitic origin. It is difficult to obtain, and is replaced in general use by the softer sulphate of lime, also known as alabaster, the two being superficially similar. Alabaster should only be employed internally and for ornamental purposes.

The term *limestone*, which properly includes the true marbles, is in practice restricted in its use to such stones, composed mainly of carbonate of lime, as are of so open a texture as to prevent their taking a polish. Even so, a wide range is covered, and many sub-divisions are possible. In physical structure alone there are wide divergences, ranging through all grades from the loosely compacted chalk, which consists of the shells of minute formaniferae, to the homogeneous Kentish Rag, the oolites occupying a middle position.

Oolitic stone as a rule is easy, and consequently inexpensive, to quarry and work, and is therefore known as a “freestone”, while it possesses uniformity of colour (generally a light cream or brown), comes to a good surface, and weathers satisfactorily. Of sedimentary origin, it lies in beds, often of considerable thickness, though the “bedding” is still visible in the blocks. Sometimes this is shown by the position of fossil shells, which always lie flat on the beds, and sometimes by markings which, if of clay, are sources of weakness. Other markings, however, frequently traverse the beds, and are due to the vertical percolation of water through fissures; and these are not to be mistaken for bedding marks. Frequently the effect has been for the water to convey carbonate of lime to a fissure, which from being a source of weakness has become a source of strength on being filled with a crystalline substance; and in other cases a similar result has been achieved by percolation of silica, though silica veinings of this sort render a stone comparatively hard to work. Lias Limestones which, practically speaking, do not necessarily occur only in the lias formations are such as include a considerable proportion of clay in their composition. They occur generally in thin beds only, and are more useful for street pavings than for building purposes, though they look well as “shoddies” rough ashlar facing blocks with freestone dressings, on account of the contrast of colour, the lias stones being generally of a dull and somewhat deep blue. The Dolomites or Magnesian Limestones are also exceedingly important impure limestones. While magnesian limestones vary greatly in composition, the true dolomite is of a peculiar granular and crystalline structure, and is known to mineralogists as Bitter-spar, consisting of 54 parts of carbonate of lime to 46 parts of carbonate of magnesia in indivisible crystals. As a rule a dolomite is fine of grain, and uniform in colour and texture, moderately easy to work, and an excellent weathering stone. Some of them contain a considerable proportion of silica in the form of sand grains, and so are, perhaps more properly, classed among the sandstones by many writers.

The *sandstones* include all stones whose grains are composed of silica. This mineral, the most abundant in Nature, assumes various forms, in some of which it is known as rock crystal, flint, chalcedony, agate, and amethyst, and constitutes not only the sands of the sea shore and the desert and the pebbles of shingle beaches, but the framework of many tropical sponges. This silica, or quartz as it is also called, being practically insoluble and of great hardness, endures when associated minerals are dissolved, decomposed, or reduced to impalpable dust. Thus the sand of which sandstones are composed has been derived either from quartzose igneous rocks such as granite, from the quartz veins of the older sedimentary rocks, from flints and from the destruction of older sandstones and beds of sand. The grains consequently vary much both in size and angularity, some sandstones being composed of grains both larger and angular, while others have very small and rounded grains, worn down to their present condition by long-continued rubbing by the action of moving water; and all degrees between these two extremes are met with. Some tropical sandstones consist entirely of microscopical diatoms, or the siliceous framework of minute marine organisms, of marvellously beautiful forms. It is thus evident that the terms hard and soft, as applied to a sandstone, have no reference to the material of which the grains are composed, but only to the stone as a coherent mass, and so depend upon the character and amount of the cementing material. This varies also. It may, like the grains, be of silica, in which case the resulting stone is white and may be very hard; or it may be of peroxide of iron, familiarly known as rust, forming a thin red coating to the grains, and giving a red, brown or yellow colour to the stone, which may be very soft or very hard; or it may be of clay, or of carbonate of lime; or it may be a combination of two or more of these substances.

3. Answer the questions:

1. What building material is this text about?
2. Is it widely used all over the world?
3. What can you say about the classification of stones?
4. What is basalt composed?
5. What do granites comprise?
6. What can you say about the properties of slates?
7. True marbles are composed of practically pure carbonate of lime in a highly crystalline form, aren't they?
8. What is onyx marble?
9. The sandstones are the most abundant in Nature, aren't they?

Text 2. Stone: its durability, selection and preservation

1. Read the following words and word combinations. Find the sentences with these words and word combinations in the text and translate them into Russian.

infinitely – бесконечно
to ascertain – устанавливать, выяснять
quarryman – каменобоец, каменотес
to chisel – высекать, высечь; надувать, надуть
sandstone – песчаник
to crumble – крошиться, обваливаться, обрушиваться, рухнуть
to elaborate – разрабатывать, отделывать
to indulge – потворствовать, потакать; увлекаться, не отказать себе в удовольствии
friction – трение
slippery – скользкий, ненадежный
grit – гравий, песок
slight – хрупкий, тонкий, легкий, незначительный

2. Read and translate the text.

To all stone users the selection of the most suitable stone for the immediate purpose of the moment is a matter of supreme importance. That the information needed may always be at hand when required, it is well to keep a cabinet of labelled specimens, each label containing not only the generic name of the stone, but a brief record of its principal characteristics, the name and address of the quarry owner, the locality of the quarry, facilities for transport, and the price of the stone on rail or ship. Such a collection may take years to acquire, but its possession will often prove invaluable. There is scarcely a stone produced that is not frequently specified to be used in a position for which it is entirely unsuited, while the same stone might in another position, and for another purpose, be the best which could be utilised. Such improper specifying leads either to substitution or dissatisfaction, and could generally be prevented by the possession of an accurately-labelled sample, which a quarry owner will generally supply if there is a genuine likelihood of the stone being used.

Colour, in particular, is a point upon which actual inspection is infinitely more valuable than description, as in all colours the various shades are innumerable. Even samples often fail here, however, for many stones vary in tint not only between different beds of the same quarry, but even in different parts of the same block. Thus if strict uniformity is required it should be ascertained in advance whether it be obtainable.

Ornamental markings, as in the veined and the fossiliferous stones, stand in this respect upon the same footing as colour; and in the case of some of the English marbles even the quarrymen do not know till it is cut what will be the colour or the marking of the next block they bring out. In other cases the markings are quite different according to the plane along which the stone is cut, some stones being exceedingly beautiful along some planes and quite dull and lifeless along others; while the fossiliferous stones often show circular markings if the fossils are cut directly across and irregular or rectangular markings if they are cut longitudinally.

Texture depends not only on the size of the grains of which a stone is built up, but on their character and the homogeneity of the mass, and is frequently of considerable importance. Most of the very hard stones, like the granites, marbles, and compact limestones, can be brought to a smooth surface, and in that condition be left plain or be highly polished, the latter being the more usual and displaying to perfection their marking and colouring. Granite, however, may be left with a roughly chiselled or even a hammer dressed surface, when its coarse and angular grain gives an effect of great solidity and strength. A somewhat similar effect can be conveyed by the use of the coarser sandstones, but it is missing with the coarse limestones, which suggest crumbling weakness if left rough, through the roundness of the oolite grains or the fragmentary stratification of the shells which they contain. Hard smooth limestones, however, like the lias, look strong when hammer dressed, exposing smooth chipped faces separated by sharp arrises; while smooth rubbed surfaces can be produced on the fine-grained sandstones and limestones alike.

Hardness is one of the qualities in a stone which most considerably affects its cost in use; for it is generally not so much the raw material which varies in price, as the value of the labour which has to be spent in working it. Thus where economy is a principal object for consideration, the softest stone which will serve the purpose should be used. Elaborate carving, for instance, can be indulged in, where it is protected from the weather and from wear, without great expenditure if a very soft stone be used; while it would very likely cost three times as much if executed in a sufficiently hard stone to withstand exposure to weather or friction.

Wear, however, in many positions demands something more than mere hardness to withstand it successfully. When used as stairs, landings, or pavements, many of the more compact stones become slippery, while others, like the lias limestones, wear into holes. An angular grit prevents slipperiness, and this is possessed as a rule by granite and the coarser sandstones. Those sandstones which occur naturally in slabs in thickness with true surfaces, are much used for these purposes.

Strength in stone is not often a matter requiring great consideration, as under ordinary circumstances any stone is capable of bearing the slight load brought upon it; but where, as in vault groining, church pillars, columns, and girder bearings, great thrusts and loads are brought to bear upon small surfaces, strength becomes of supreme importance. In this matter care is necessary, for the results of tests upon small sample cubes are extremely deceptive, except in the case of the higher grade stones of uniform structure.

Correct bedding is, in the case of most of the laminated stones an absolute necessity. In ordinary walling, bearing a vertical load only, the beds should lie horizontally. Were horizontal bedding attempted, however, with undercut mouldings, the undercut portion would flake off, as shown by dark lines in the illustration, and so edge moulding is resorted to, with the beddingparallel to the vertical joints. Face-bedding, as it is called when the bedding lies vertically and parallel to the face of the wall, should never be used, as the surface tends to peel off. In the case of stones resisting heavy thrusts, the bedding must be at right angles to the thrust, as it is in this position that all stone is strongest to resist. A skilled mason can generally detect the bedding of a stone at sight, by noting that fossils lie flat on the bed, or by small bed markings; or if these fail he can “feel” the bed when he works the surface with his chisel. The inexperienced, however, are likely to be deceived by mere water veinings.

The *size* of slab and depth of bed obtainable are important factors in determining the selection of stones for many purposes, where large sizes are needed. Many otherwise excellent stones are obtainable only in comparatively thin beds. As a rule special inquiry upon this point is necessary, else much trouble and delay may result.

The *durability* of a stone used externally seems to be a matter which can properly be determined by experience only. Where subject to the action of water and of marine insects, as in sea walls, weight and hardness are essential to durability, but in general building work this is not the case, many stones of comparatively light weight and open structure being known to be excellent weathering stones. Water may penetrate into the pores of some stones, freeze, expand, and blow off fragments; but this is an infrequent occurrence, except with the very softest, which few would think of using. Similarly, in theory, limestones should not be able to resist the action of the acids contained in the air of all large towns; yet there are many nearly pure limestones which experience shows can be used with perfect safety in such places as London and Birmingham. Tests, whether mechanical, chemical, or microscopic, seem to be of little value. It is better not to trust to them, but to be guided by the results of the many experiments which men of previous generations have made, assuring yourself that you really are using practically the same stone as that in the building you trust to, and from the same quarry bed. Most quarries produce stone of several qualities, usually, though not invariably, the better weathering and harder stone underlying that of less value.

Even *absorption* is not an entirely reliable test of durability, and certainly not as between class and class of stone. Walls built of absorbent stones are, it must be remembered, liable to be damp walls, especially if the stones be compact of structure as well as absorbent, and so of a nature which prevents their parting readily in fine weather with the water they have absorbed during rain. Such a stone will probably, on microscopic examination, be found to contain minute fissures along which water will be absorbed to a considerable depth by capillary attraction. A wall built of such stone will be more permanently damp than one composed of stones of more open grain, which absorb even a larger proportionate weight of water; for water penetrates further and is retained longer in fine cavities than in larger ones.

Several means of *preserving* the less durable stones have from time to time been suggested, painting either with lead paint or with oil being the most common, and requiring periodic renewal. Two liquid preparations of secret composition Szerelmey's and the "Fluate" of the Bath Stone Firms have also been much used for this purpose; but they are more valuable for rendering absorbent stones somewhat waterproof than for preserving them. It is better to use a durable stone in the first instance than to trust to these or any other preservative. They have, however, the advantage over other preparations of being colourless and not affecting the appearance of the stone to a material extent.

Of *destructive agencies*, water is the most to be feared, either from its proverbial "wearing" action, which is mechanical, and whose effect is seen in sea walls and on the “weather” side of buildings in exposed situations, or from its action as a solvent carrying destructive acids present in the air of large towns into the body of the stone, or from its expanding just previously to freezing after having been absorbed, and so splitting off small fragments of stone. Lichens, mosses, ferns, and creepers are also highly destructive, especially to limestones, both through the penetration of roots into the pores of the stone, and through the vegetation holding water like a sponge, and so giving time for any acid the water may contain to act. Water is thus again the actively destructive agent. Lodgment for it should never be provided, and such things as hollow mouldings, water-holding carving, and soffits unprotected by drips should be studiously avoided in external stonework. Stone is a weight-carrier, with little transverse and less tensile strength. Use it, therefore, freely in compression, with caution as lintels, and never in tension. Bring pressure upon it at right angles to its natural bed, or, in the case of slate, to its cleavage. Arrange that each stone may be cut with as little waste as possible out of a roughly rectangular block, such as is obtained from the quarry. Mouldings and carvings cannot be planted on. The effect must be obtained by sinking the hollows below the natural surface. Avoid elaborate and undercut detail in the harder and in the laminated stones. Avoid sharp arrises in the more friable stones, and where exposed to rubbing or weather.

3. Answer the questions:

1. The selection of the most suitable stone for the immediate purpose of the moment is a matter of supreme importance to all stone users, isn’t it?
2. Does stone texture depend on the character and the homogeneity of the mass?
3. What can you say about such stone quality as hardness?
4. How do you understand the word combination *correct bedding*?
5. What is the most destructive for stone body?

Text 3. Basalt and granite

1. Read the following words and word combinations. Find the sentences with these words and word combinations in the text and translate them into Russian.

prism – призма
indestructibility – неразрушимость
sedimentary – осадочный
potash – поташ
mason – каменщик, каменотес

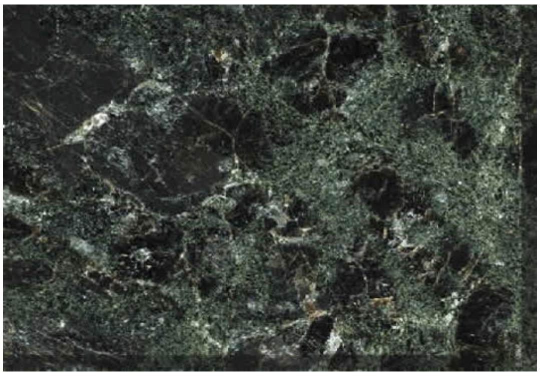
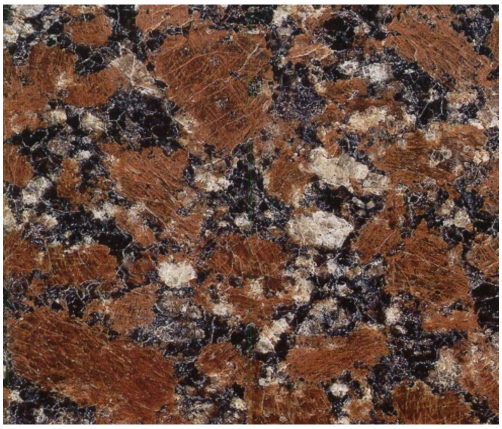
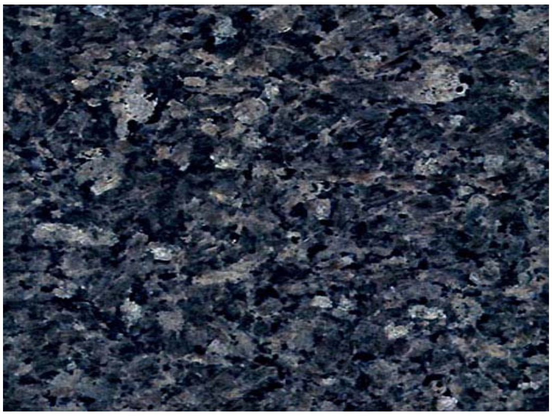
to disintegrate – дезинтегрировать, распадаться
gneiss – гнейс

2. Read and translate the text.

Basalt, being hard and difficult to work, and mostly found in places from which transport is difficult, is little used structurally; and, as it has never been worth while to put down expensive plant, the method of quarrying is elementary. Owing to its columnar structure, it comes out of the quarry in long prisms. These, if placed on their sides and bedded in cement, make an excellent facing for sea-walls, where weight and indestructibility are primary considerations, and for this purpose they have been used in some parts of Ireland. A decorative dark green Basalt which comes out in large beds, splits readily, and polishes well. Used structurally, it makes good hammerdressed walling, especially for plinths and basements.




Granite, generally considered as igneous and intrusive, is, however, thought by many to be of sedimentary origin. It is a holo-crystalline aggregation of quartz, felspar and mica, its chemical composition varying with its mineral contents; and no less than 44 accessory minerals occur in it in varying proportions. Orthoclose, or potash felspar, is generally its principal constituent; its colour varies from white to flesh-red, and its grains are irregular and sharply defined. It is usually thought to be a weather stone of undoubted quality; but this is not by any means always the case. Some granites are no better weather stones than the softer oolites, crumbling in the hand after a few years' exposure, and although most English and Scotch granites are reliable in this respect, the opinion of a mason accustomed to granite working should be sought where doubt exists. If exposed to fire it disintegrates badly.

Gneiss is a rock which has the same mineral constituents as granite, but is more or less stratified. It is very little used in building. Granite is extensively worked, generally in large, open quarries. The beds as a rule are very thick; but still, horizontal beds do occur at intervals, and these often contain a very thin layer of sulphur. If, as sometimes happens, vertical joints of the same nature are found, the great natural blocks can be wedged apart. Otherwise, and more frequently, it is necessary to blast. Vertical holes are driven downwards, close against the new quarry-face which it is desired to expose, the quarry being worked in rough steps, as shown on sketch. These holes are made with a "jumper", which is a tool like a long bar of iron, weighted at about one-third of its length from the point with an attached ball of iron, and having a chisel edge. This the workman merely lifts, turns slightly, and drops, so that drilling a blasting hole is a slow process. After the circular hole has been made to the required depth, a notch is cut throughout its whole length in each direction in which it is desired for the rock to split. The number and position of these holes vary according to the block required, the charge, generally blast gunpowder, is proportioned so as to split the rock where required and lift it forward without unnecessarily breaking it up, and all the charges are exploded simultaneously. In many quarries, if the blocks have not been thrown over the old quarry-face by blasting, they are now levered to the edge till they fall over, and are removed from its foot by cranes and trucks, or by a more elementary system of wood rollers; while in other quarries it is necessary to use large cranes and lift theblocks to the top for transport. Rough irregularities are, however, always first knocked off with a heavy hammer, or the stone is split up into smaller blocks or slabs by making a series of holes, less in depth, larger in size, and closer together than the blast holes, and driving peculiar wedges into these. Two “feathers” are first inserted, these being of steel and resembling shoe-horns in shape, and then a steel “plug”, in the shape of a truncated cone, is driven in between the feathers. The several plugs in a series have to be tapped in succession to ensure even driving and an uniform split. Sawing, such as will be after- wards described when dealing with marble, is sometimes resorted to for producing slabs, but it is a tedious operation; and the same may be said of turning. After splitting roughly to size with the plug and feathers, the next process is that of reducing surface irregularities with the scabbling hammer and has a short handle. The flat, or “spalling”, face is for knocking off irregular lumps and angles, or for roughly “hammer-dressing” the surface, while the pointed or “pick” face is applied vertically to the surface, being just lifted and allowed to drop of its own weight, this action being repeated rapidly by a skilled workman and soon reducing a rough to a comparatively smooth surface, chips flying off in all directions. If the scabbier has two pick faces, and is known as a scabbling pick, it is somewhat lighter in weight, finer work being possible with it, while finer work still can be done with a pick having toothed edges, known as a serrated pick, or with an axe. It is this tool which is generally used to produce the so-called “draughted margins”, with their parallel tool marks close together, though the same effect can be produced more tediously by means of a chisel. The finest face, short of polishing, is obtained on Granite by the patent axe, which consists of a bundle of steel plates bound together, so that they can be taken apart and their edges sharpened when necessary. Heavy machinery is necessary for polishing economically on a large scale. The fine axed surface has to be ground down by rubbing on a revolving or travelling table in sand, the weight of the granite, which lies on the table, applying sufficient pressure. This rubbing is repeated, with material of finer and finer grain, until the surface becomes of that absolute smoothness known as high polish, the granite, during these later processes, being fixed, and movement being imparted to the rubbers. Granite is used largely in building operations wherever stone is required to carry a heavy load or resist constant friction, as in plinths, columns, and pavings, while much is also employed for merely decorative effect. The waste blocks and chippings are commonly utilised also, the larger as road metal, and the smaller as the aggregate for concrete and artificial stone, so that the ultimate proportion of waste from a granite quarry is small. Devonshire and Cornish granites are mostly grey in colour, with distinct black and white crystals, that from the De Lank quarry, six miles from Bodmin, being typical, very hard and durable, and with a well compacted grain, in which hornblende abounds. Farther west, however, near Penzance and the Land's end, the granite is of a moreyellow colour, and contains large felspathic crystals known as “horses' teeth”. This is known as Porphyritic granite, and is highly decorative when polished. That from the Blackenstone quarry is typical. Granite from the Channel Islands is close in grain, sometimes of a bluish tinge, and generally very hard. Leicestershire granite is a true syenite. It makes excellent road metal, but except locally is not much used for building, being tough and compact, except as the aggregate for artificial stones and concrete. It is often green in colour. The grey granite fades more or less after continued exposure. It is composed of small grains. A large amount of excellent granite, grey, blue and red, is now imported from Norway and Russia, as, owing to the low rate of wages obtaining in those countries. Amongst this is a granite, nearly black in colour, containing large crystals, which have a peculiar “flash” when polished, which, if introduced sparingly, may be used amongst other stones with good effect. There is doubt whether these foreign granites will retain their polish and colour well externally.

3. Answer the questions:

1. What building materials is this text about?
2. Is basalt hard and difficult to work?
3. Why does basalt come out of the quarry in long prisms?
4. What can you say about the method of its quarrying?
5. Where is basalt used?
6. What does granite consist of ?
7. What does the colour of granite vary from?
8. What is gneiss?
9. What countries is granite imported from?

Text 4. Slate

1. Read the following words and word combinations. Find the sentences with these words and word combinations in the text and translate them into Russian.

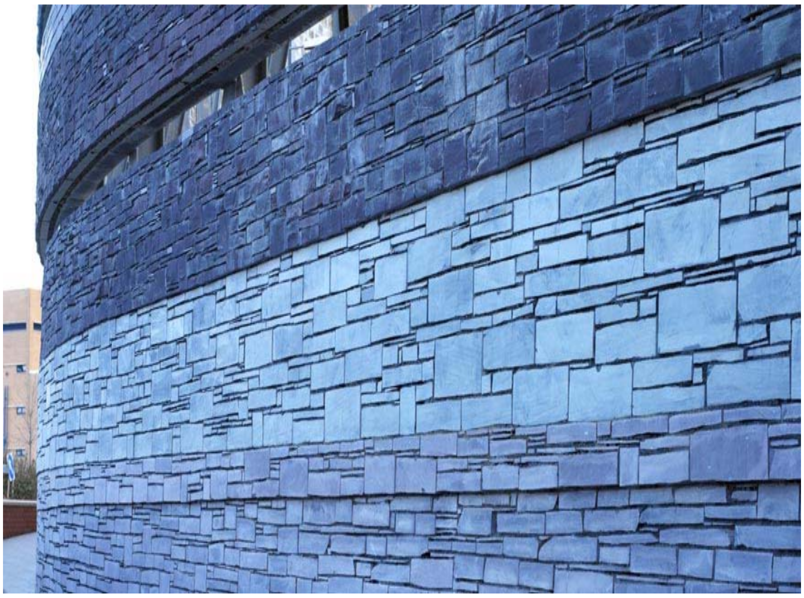
slate –сланец, шиферная плитка
slate quarry – сланцевый карьер
blasting – подрывные работы
to chip – стругать,откалывать

cleavage – расщепление, раскалывание, раскол, расхождение
pillar – столб, опора
chisel – резец, стамеска, зубило
outcrop – обнажение пород
ascending system – восходящая/возрастающая система
to dislodge – смещать, выбивать, вытеснить

2. Read and translate the text.

There are two methods of obtaining slate by open quarrying and by mining. Whichever system is employed for reaching the slate, however, the process of dislodging it is that of blasting. When a quarry face has been exposed, a vertical channel about 3 ft. square has to be chipped out throughout its height. A horizontal hole has now to be made at a convenient depth, known as a “split hole” along the cleavage and preferably in a natural joint, and a carefully proportioned blast exploded in this just to lift the rock. Then another hole, known as a “pillar hole” is driven in at right angles to the cleavage and down to the “split” caused by the previous charge, thus bursting the stone out at the split and towards the already exposed channel along an imperfect cleavage, perfect enough for this purpose, called the "pillaring line" which always runs north and south. The blast holes are made with the jumper when vertical, and when horizontal or nearly so with a long chisel (with shield) and a hammer, the men having often to let themselves down by ropes to their work. Almost invariably a tunnel is driven in from the outcrop under the granite roof, with branches at convenient depths, from which chambers are worked under one another, the chambers being 30 ft. wide with 30 ft. pillars of solid rock left between. Thus only half the rock contained in a slate mountain is ever removed, owing to the necessity of leaving these pillars to support the roof above. This is known as the descending system. At the Rhiwbach quarry, near Blaenau-Festiniog, which produces roofing slate only, an attempt is being made to reduce the enormous waste often 14 tons of rock having to be removed to produce one ton of finished slates by working on an ascending system and using a machine wire saw instead of blasting. A steel wire rope, J in. in diameter, running in granulated slate and worked by compressed air, is made to take off a clean slice of rock face no less than 150 ft. in length, and this, once cut, may be split up into convenient sections along the cleavage and the pillar line with heavy broad-edged wedges. The blocks thus dislodged are split along the cleavage, by wedges or plug and feathers, into slabs of not more than 13 ins. thick and then taken to the workshops or “mill”. There the slabs are first sawn into lengths, according to the purpose for which they are required. Circular machine saws are used, the stone being brought to them on travelling tables. Thin slabs can be cut by toothed saws running in water, but the thicker slabs are cut by a saw having steel scupper nails set into the blade to serve as teeth, the rotation being so arranged that the head of the nail first meets the slate and acts as a cutting edge, forming a broad groove. Whichever form of blade is used, there are two blades on each spindle acting simultaneously against the same slab, and so cutting exact lengths, which are adjustable. A hand saw, having a few V-shaped notches in place of teeth, and working in water, can also be used, but its employment is more tedious. For many purposes for which slate is used, such as for shelving, cisterns, hearths, paving and urinal sides and backs, the widths as well as the lengths are sawn, and one or both faces arc planed. This is done by passing the slabs, resting again on a travelling table, under a broad plane iron, 8 ins. or more wide, set in a frame so as to take off any desired thickness of shaving, and the surface thus produced can if required be further smoothed, or "polished" as it is called, though no really polished face results, by rubbing with pumice stone. By altering the planing iron any desired moulding or groove can be cut; and it is in this way that slate ridge rolls are made. Chamfers, and mouldings also, can likewise be cut by hand with a large-headed wooden mallet and steel chisel, such as is used by masons for softer stones, and finished with a file and emery paper or rounded nosings are even filed only, without previous chiselling. When required for roofing, the slate slabs sawn to length are split along the cleavage to not more than 3 ins. thick, and then "pillared", or split across the cleavage with a pillaring chisel, having an edge about an inch wide, driven with a heavy iron hammer. The slabs thus roughly reduced to size are now taken between the knees of the splitter. He gauges the thickness of a slate by eye, varying it according to the class of rock he is dealing with, and drives in a splitting chisel, having a thin, wide blade, along the edge with a light iron-bound wooden mallet. Very thin slabs of the higher quality slates are obtainable, and the splitting is, as a rule, readily done by a trained man. The slates thus obtained are trimmed to market sizes with a dressing knife acting against a travel, this last being a tool resembling a door scraper with a knife edge the sizes being first marked on the slate by a nail in a notched measuring stick, the notches being graduated to give every inch from 6 to 18, and then 20, 22 and 24 ins. In many quarries trimming is now done by machinery, with what look like gigantic scissors whose lower blade is fixed horizontally while the upper blade is made to rise and fall. A fixed plate against the side determines the right-angle, and against this the notched measuring stick is also fixed.

Roofing slates are sorted at quarry according to size and weight, and not according to the trade names by which certain sizes have become known; and the sizes obtainable are much more varied than is generally supposed. While the larger sizes only are used in London to any extent, they are scarcely known in the North of England and Scotland, where small sizes are much preferred: Roofing slates are known as "Firsts", "Seconds" and "Thirds", the quality depending on freedom from flaws as well as upon evenness of colour and thickness, it not being always the thinnest slate which is the best.



If good slate be stood in water, the damp should not rise at all perceptibly up its edgeabove the water line, even in 24 hours; while in a bad slate it will rise as much as 2 ins. in ten minutes. A bad slate, also, will give off an earthy odour when wetted, and when struck will sound dull, while a good slate gives off a sharp metallic ring. Slates are sold from the quarry by “long tally” that is, per thousand of 1,200, with 60 extra to allow for breakage, making a total of 1,260 to the thousand. By the time they reach the builder, a thousand usually consists of 1,200 only.

The specific gravity of slate, like that of all other compound minerals, varies slightly. The tensile strength, rarely called into play in practice, is about 630 tons per square foot, and its crushing strength varies from 720 to 1,205 tons per square foot. As to its transverse strength, this is difficult to express, and it can only be said that it is such as to render it the best of all stones for use in weight-carrying lintels. Easily split, planed and sawn, it is yet extremely tough and wear-resisting. There is a great amount of wastage both in quarrying and working, no use for the detritus having yet been found, save that the larger blocks of rock which, containing hard veins or otherwise, are useless for conversion, are employed for walling in the locality of the quarries. In somedistricts, iron pyrites are found in the slate beds, and cause a great deal of trouble to the quarry owners; but roofing slates and slabs containing them are rarely put upon the market. "Best" or "First" slates, according to the general acceptance of the term, must be thin, of straight cleavage and good colour, and free from spots; but above all they must be thin. In this respect the classification is unfortunate, for while thin slates make very light roofs, they are liable to breakage, and the monotonous smoothness is hardly so pleasing, to many architects, as the comparative roughness of a thicker slate. Thin blue slates are principally shipped from Bangor, and are known as "Bangor slates". "Best Bangor" are perhaps the finest slates procurable for perfect uniformity of colour, smooth texture, and extreme thinness. "Portmadoc slates" are also named from the port of shipment, as they are not quarried at Portmadoc, but in the neighbourhood of Festiniog. They are slightly thicker and coarser in grain than "Bangor slates" and of a more purple colour.

Though free from blemishes they are classed as "Seconds" and "Thirds" only, as they are not thin splitting. Where a little additional weight is not objected to they make admirable roofing slates. The colour is a pleasant dark blue. Very large slabs are obtainable. Blocks can be sawn up to 14 ft. square and planed up to 12 ft. by 6 ft. A green slate with a peculiar permanent red flash upon the surface is quarried at Precelly, in South Wales. Westmorland slates, especially those from the Elterwater and Tilberthwaite quarries, are of a beautiful green colour, thick and rough. They are not arranged in sizes before being sent from the quarry, and so have to be purchased "mixed". Usually the longer slates are laid near the eaves of a roof and the smaller ones near the ridge; and as the widths as well as the lengths vary, broken jointing results. Laid by skilled hands this can be made to look very well. These Westmorland green slates are not clay formed, but are composed of volcanic ash which has been altered by metamorphism. Though good slates are obtainable from Cornwall, Scotland and Ireland, they are not much used except locally. Soft, earthy slates are also quarried in Somersetshire, but they are not of great value for roofing purposes. The Irish slates are particularly good, and occur in large quantities, but the difficulties of transport are great, and seem to prohibit their use to any great extent. They are all purple in colour.

American slates have been imported and largely used in cheap work of late years. They are mostly blotchy, and of unpleasant purple, green, or red colour. Portuguese slate is imported, mostly for enamelling for it lacks some of the qualities necessary for a good roofing slate. It is somewhat earthy, but is soft to work, is easily brought to a smooth surface, and stands well the temperature of the ovens. Enamelled slate is used principally for chimney pieces. The slate, after being planed, is placed on a rubbing bed before the colour is applied. The colour first used is black, and with this the whole surface to be enamelled is covered. As this is done, the slabs are arranged in iron racks so that the air can get all round them, and the racks, running on tram lines, are wheeled into large ovens and subjected to a dry temperature of about 300 degrees F. On removal, any desired colours are applied by skilled enamellers, either to imitate marble veinings, or to produce patterns or even landscapes, the "brushes" used including coarse sponges and feathers. Stoving is repeated, sometimes only once, but usually more often, lower temperatures being used for the colours than for the black groundwork; and the work is finished by varnishing and polishing with rotten-stone. The various slabs which compose fire-place jambs are fixed together before they leave the works, hook-shaped iron cramps being screwed and leaded into the back of the slabs and these held together with a plentiful supply of plaster of Paris, in which lumps of broken marble are embedded.

3. Answer the questions:

1. What do you know about methods of obtaining slate?
2. Is blasting used when quarrying slate?
3. Are roofing slates sorted according to the trade?
4. What can you say about the properties of slate?
5. Usually the longer slates are laid near the eaves of a roof and the smaller ones near the ridge, aren't they?

Text 5. Marble

1. Read the following words and word combinations. Find the sentences with these words and word combinations in the text and translate them into Russian.

to lever – поднимать рычагом
invoice – накладная, счет-фактура
gantry- рама, помост, портал подъемного крана
shed – навес,сарай,ангар,гараж,депо; распространять
premises – помещение, дом
slab – плита,пластина
saw – пила; пилить
hopper – засыпная воронка; самосвал, вагон; фрамуга
sieve – сито, решето; просеивающая машина, просеиватель

2. Read and translate the text.

Marble is in some cases easily quarried, as it occurs naturally in blocks of convenient size, needing only to be levered out; but more frequently blasting or wedging have to be resorted to. Foreign marble generally reaches England in roughly-squared blocks, but the more valuable statuary marble of Italy is sent over just as it is obtained from the quarry, and is invoiced neither by weight nor cubic content, but simply as “One block of Marble”.

Marble masonry is a thing to itself, requiring heavy machinery and infinite patience. The blocks are lifted from barges by a crane running on a gantry, and are deposited under cover in a large shed, the power employed for this and all the other machinery being electricity generated by a dynamo driven by a gas engine, the gas for which is made on the premises. When it is required to cut a block into slabs it is put upon a table at ground level and a series of steel blades are suspended horizontally over it in a rocking frame, at such distances apart as correspond with the thickness of the slabs required. As these blades, or saws, swing horizontally, they are supplied with fine sand from a hopper in which rollers revolve to crush any coarse particles, the sand passing from the rollers to a fine rocking sieve, through which it is washed with a plentiful supply of water. In this way as many as twenty, or even more, blades can be worked simultaneously upon the same block of marble, but even so the process of sawing is extremely slow. In order to cut the slabs thus produced to their required sizes, several are piled on one another till a depth of about 12 ins. is reached, and placed on a slow travelling table in front of a circular saw. This has a steel blade with diamonds set in sockets on its edge, and does its work with comparative rapidity, the rate of “feed” being adjusted according to the total thickness to be cut through. Water only is supplied to this saw. The edges are next ground on a revolving iron table in sand and water, and the square slabs are then bedded in plaster of Paris on a wooden frame, to a perfectly true surface, on a setting of brickwork. Over this frame is a revolving arm to which can be attached revolving rubbers of various kinds. The first of these to be used has iron pads, which work in sand to grind down minor surface irregularities and remove any rust stains left by the saws. This acts for eight hours, moving rapidly over the face of the marble and attacking all parts equally, and then is replaced by a rubber having rope pads working in emery for another eight hours, the final polish being applied by a rubber with felt pads working in putty-powder (oxide of tin) for a similar period of time. Straight mouldings, if started by hand, can be cut by machine on a travelling table under narrow plane irons, but on curves they have to be worked laboriously by chisel and mallet, as must all carving and sculpture. All the various grinding and polishing processes on such work is also done by hand and exceedingly tedious it is sand being first used to remove the tool marks, then pumice-stone, then snake-stone, and finally putty-powder. Columns, however, even up to 16 ft. in length, can be turned and polished by machinery, even the entasis being given in a way which needs little after working to correct; but breakage sometimes occurs in the machine, entailing heavy loss.

Most of the white marble now used for statuary comes from Italy. Carrara marble is best known, with its sugar-like structure, but the Serverezza marble, which is glassy rather than saccharine in fracture, is almost to be preferred. Of late years a white marble, slightly veined and so not suitable for statuary, has been imported from Norway for use in thin slabs as wall linings and counter tops. Most of the veined marble in common use at present comes from the Pyrenees, whence many colours and most beautiful markings are obtainable, impossible to classify, and only to be selected from samples. The best known coloured Italian marbles are yellow, that from Verona light and pure in tone, and that from Sienna of deeper tint with purple markings. Greece produces a very fine green marble, known as Cippolino, which, however, requires expert cutting if the marking is to be displayed to advantage. The most beautiful marble known, probably, is also green, with crystals of white set in it as if it were a natural mosaic.

This marble is often referred to as “porphyry”. It is easily distinguished as being a “breccia” of angular fragments of light and dark greens, with pure statuary white, the whole being cemented together with a brighter green, while the snow-white patches usually have their edges tinted off with a delicate fibrous green radiating to the centre of the white. The cementing material is also of the same fibrous structure. Another beautiful green marble is the Connemara, from Ireland, but it is not obtainable in very large blocks; and other true Irish marbles are the rich Cork red, the Kilkenny black and white, and the Galway black. Many different colours are obtainable, the tints being as a rule delicate rather than striking, making it suitable for internal wall-linings, chancel floors and steps, and other decorative uses. Purbec "marble" is really a hard, South of England limestone, capable of receiving a good polish, which, however, it does not retain very well. It is of a deep blue colour, with fossil shells well displayed, and, though little used now, it was emplyed largely in the thirteenth and fourteenth centuries for small detached shafts, bases and string mouldings. Somewhat similar stones, though lighter, and sometimes yellowish in colour, are found in Derbyshire, in larger slabs than the Purbeck, rendering them useful for steps, floors and wall linings. Such is the fine-grained Hoptori-Wood stone, which comes out in large blocks and weathers well; and also the beautiful fossiliferous Barton Limestone. Dark blue or grey as Madrepore marble. It is composed entirely of fossilized shell-fish Dorsetshire. about the size of a pea. It has been largely used in nearly every cathedral in England for columns, and is to be found in many ancient churches for fonts, etc. It occurs in beds from 6 to 9 inches thick. It can be easily got in almost any size; depth of bed, 20 ft. There are three beds: the middle is called the “London bed” and exported; blocks 5 ft. to 10 ft. long and 4 ft. to 5 ft. wide, sawn on the spot into slabs, etc. This limestone takes a tinged with; good polish; makes blue excellent lime; is capable of being worked to any shape; has no “crossway”, that is, it works freely to the tools in any direction. Some varietie clouded; used for polished work, chimney-pieces, etc.

3. Answer the questions:

1. Is marble easily quarried?
2. What statuary marble is more valuable? Italian or English?
3. Which machinery does marble masonry require?
4. Marble masonry is a thing to itself, requiring heavy machinery and infinite patience, isn’t it?
5. How are the marble blocks delivered?
6. What kinds of marble can you mention?
7. What do you know about Cippolino marble?

Text 6. Limestone

1. Read the following words and word combinations. Find the sentences with these words and word combinations in the text and translate them into Russian.

crowbar – лом, вага, аншпут (*рычаг*)
mallet – деревянный молоток, колотушка
chisel – резец, долото, стамеска, зубило
to resort – прибегать к чему-л., обращаться к кому-л.
detritus – детрит (*продукты выветривания горных пород*)
outcrop – обнажение пород, выявление
shaft – ручка, рукоятка, черенок; колонна, столб; шахта
pillar – столб, колонна, стойка, опора
freestone – незакрепленный камень
pickax – киркомотыга, кайла
groove – желобок, паз, прорез, шпоночная канавка; шахта, рудник
to squeeze – (вы-)сжимать, (вы-)сдавливать, втискивать; протискиваться
solid – твердый, сплошной,массивный, цельный
a natural joint – естественный шов, трещина

2. Read and translate the text.

The method of quarrying limestone necessarily varies considerably, as does the stone itself. Where, like the Keinton stone, it occurs near the surface as a homogeneous stone in thin, well-defined horizontal beds, having good natural joints, little more is needed than to lever it out with crowbars and lift it to the surface, the quarry being worked in floors rather than faces. The subsequent working is equally simple, being mostly done with the hammer, or with mallet and chisel, to produce an approximately fair face, machinery being little resorted to. The detritus can be crushed for road metal or burnt for lime, so that if the quarries were well situated for transport and the lime could be sold at a profit there would be little waste. This not being the case, the waste is considerable. As a contrast to this, the various Bath stones are mined. They occur in deep beds, up to as much as 22 ft. in thickness, which rarely outcrop, but have to be reached by long inclined shafts sunk in the hill side. Pillars of hard stone of little value occur at intervals, and these are left to support a natural roof of hard rock, while the bed of freestone is removed. Between the freestone and the roof, at any rate in the Monk’s Park quarry which was visited, there is a thin layer of rubbish, which is first removed with pickaxes, some of which have very long handles, enabling a depth of 5 ft. to be reached. This done, a vertical cut is made down the side, against the hard stone, with a long toothed hand-saw, held horizontally and worked with one hand. A second similar cut is made to form a V groove, wide enough for a man to squeeze into, the stone between the two cuts having to be chipped out as waste if, as is usual, it will not come out solid. Then a man standing in the groove saws downwards at the back of the space picked out, and finally a third saw-cut separates the block, all these cuts being taken down to a natural joint. A roughly rectangular block is thus produced, almost free from waste, and this can be levered out and lifted by cranes on to trucks running on trolly lines through the mines to the foot of the shafts. Bath stone, at least that from quarries owned by the Bath Stone firms, which is dislodged during the winter months, is kept in the underground workings till the spring, so as not to expose it to frost while the quarry sap is in it. When brought to the surface every block is tapped all over with a pebble. If it gives off a ringing sound, the block is a good one, but if the sound be dull a vent is indicated, and its position is then located and it is cut out before the block is sold. There is scarcely any waste from a Bath stone quarry, especially as the "venty" blocks and the smaller pieces are squared and sold as holy-stones for cleaning ships'decks. In the subsequent working of limestones, the circular, rocking, and hand saws are all used, with or without teeth, according to the hardness of the particular stone, sand washed in with water replacing the teeth when the toothless saw is used. Machinery is not often employed, at any rate for the oolites and dolomites which are soft enough to be profitably worked by hand, except in large works, where a circular rotating rubbing bed of iron, on which the stone rests in sand and water, is used to remove saw marks and produce a plane surface. In smaller works, rubbing is done with a piece of sandstone by hand; or else a plane face, or nearly so, is produced by scraping the surface with a thin metal comb known as a drag. Sinking, moulding, grooving, etc., are all performed with chisels, varying from the point to the boaster, the latter having an edge 2 ins. wide or more, intermediate sizes alone being known as chisels. These names are, however, liable to local variation. In many parts of the country there exist groups of small limestone quarries, little known beyond their own locality, but producing stone of excellent quality. Of these, the Rutland group may be taken as an example, comprising the Barnack, Ketton, and Casterton stones, whether "free" or "rag", of which the Barnack Rag, of which many cathedrals and churches were built, is no longer procurable. The Casterton quarries, near Stamford, were inspected, and may be described as being typical of many other small quarries. They are open workings of no great depth, overlaid with fireclay, which is removed for burning into adamantine clinker, beneath which is a thin layer of useless stone above two beds of good freestone, composed of rounded grains cemented together by carbonate of lime, each with a maximum depth of 3 ft. 6 ins. When first quarried the stone is soft to work, and friable, but it acquires a hard surface on exposure, andweathers well, in a country district at any rate. The bedding is difficult to detect, but immaterial, as the stone may be laid equally well in any direction a very useful quality for undercut moulding and carving. The colour varies from white through quiet shades of pink and burf, and the supply is limited to some 200,000 cubic feet per annum, the largest block obtainable containing about 80 cubic feet. The following analyses of true limestones, dolomites, and siliceous dolomites are instructive, bringing into strong contrast the distinguishing characteristics, chemically speaking, of these stones: Typical Stones, Carbonate of Lime, Carbonate of Magnesia, Oxide ot Iron and Alumina,Water, Bitumen.

The three stones known as Mansfield, vary much both in colour and composition, while in other instances the stone from different beds of the same quarry are entirely distinct. It consequently happens that in any classification of limestones, the same name will sometimes occur in two different lists. There are so many varieties of limestone that they have to be distinguished in some way. Custom has based a nomenclature for them, rather irregularly, on their physical condition, mineral contents, and stratigraphical relation to other rocks, and sometimes on the three combined. Limestone can be crystalline or amorphous, compact or fissile; it may be pisolitic, oolitic, concretionary, or shelly; there are argillaceous, siliceous, bituminous, and dolomitic varieties; others may be brecciate or coralline, whilst there is no end to the names they derive from their relation to other rocks in the sedimentary strata it will be sufficient to mention the Silurian, Devonian, Carboniferous, Lias, and Tertiary limestones as examples of this class of names. Again, limestones are called after the localities in which they are found: these are Woolhope, Wenlock, Derbyshire, Bath, Portland, Purbeck, and Bernbridge limestone, these local names being in some cases compounded with others, as for instance Bath oolite, Portland oolite, Wenlock concretionary, etc. Hard and highly fossilift-rous, the fossils giving a spotted appearance; takes a polish. Very fine close grain with a texture like chalk; works to a very smooth surface. Used at Gare d'Orleans, Paris. Very even grain; works to a smooth surface.

Sandstones are all worked in open quarries, either by levering and wedging, where the lamination is thin and the beds distinct, or by blasting when the stone occurs in rock masses, the processes generally being very similar to those already described, and the thinner slabs of softer stone as a rule overlying the thicker blocks of compacted rock. After quarrying, the stone is not only shaped to rough block, but is often completely worked up ready for fixing in position at the quarry side, where there are the proper machinery and workmen skilled in the manipulation of the particular stone produced, most of the sandstones being sufficiently hard to stand a railway journey after being worked without serious risk of being chipped in transit. There is not much waste, as the chippings can be used as road metal, or crushed for concrete. Sawing is accomplished either with circular saws (those with scupper-nail teeth and of large diameter being used where the blocks are thick, as are those of the Forest of Dean stone) or with toothless horizontal rocking blades, supplied with a mixture of water, lime, and chilled steel shot, the lime being required to remove rust stains caused by the steel blades. Straight moulding is done mostly by machinery with plane irons, but face work, rounded mouldings, and mitres are worked by hand, the first for economy's sake and the last because a true mitre is difficult to make by machine.

One of the best sandstones in the country is that known as Blue Pennant, found at Fishponds, near Bristol. It is of a moderately deep blue colour, obtainable both as slabs up to 12ft. by 8ft. from the upper beds, and as blocks having a thickness of as much as 2oft, the sizes obtainable being only limited by the capacity of the lifting machinery. In every way it is an excel ent stone, hard, strong, coming to a fine surface, and weathering and wearing well; but its hardness makes it difficult to work, and it is consequently expensive. Hammer-dressed locally known as "Polled Pennant" it makes excellent "shoddies", or rough wall facing, while more highly worked it can be employed for all purposes for which stone is useful, for facing, quoins, sills, lintels, hearths, steps, landings, columns, and bed stones. Not quite so hard as the Bristol Pennant, and consequently not so costly, it possesses the same good qualities of good face, wear and weathering, combined with large size, though the colour is scarcely so uniform, ranging from blue to grey; and the thicker blocks even if grey outside gradually change to blue in the centre, while the blue sometimes runs into brown. It is much used for girder beds and templates, monuments, steps and landings, and in bridge construction and dock work, all the ashlar and copings at Avonmouth Docks being of this stone, and all the stonework at Tidworth Barracks on Salisbury Plain. Red Forest of Dean stone comes from Mitcheldean, on the borders of the Forest. This varies from a rich deep red, which is soft enough for general work, being not much harder than the blue from Coleford, to a very light red, which is nearly as hard as granite and almost too hard for mouldings and ornament, the colour and the hardness varying together. Layers of marl and stone alternate in the quarry.

The Quarella stone, from Bridgend, in Glamorganshire, occurs in quite a small patch; but it is a very good stone, and large blocks are obtainable. There are three distinct beds one a beautiful light green suitable for general work, and very useful decoratively; the second, known as ”Ryder,” varying in colour and only useful for cottage work; and the third a very hard white stone obtainable in large blocks. All the above, as well as the red sandstones of Cheshire, several of the Yorkshire stones, and the Scotch stones, both from the Dumfries and the Edinburgh district, may be classed as *general building stones*. For practical purposes, the other principal classes of sandstones are the hard coarse-grained grit stones, suitable for engine beds and heavy engineering work, and the thin-bedded, laminated stones, used largely for paving slabs, steps and landings. Of both these classes there are large deposits in Yorkshire, and only smaller ones elsewhere, with the result that upon the London market the term ”York Stone”has come to be considered as synonymous with “Sand-stone,” and includes many different varieties and qualities. Another stone which demands special mention is that to which the trade name of “Shamrock” has been given, from Liscannor, Ireland. It is a hard, clean grey mill-stone grit. The formation is peculiar. The stone is in enormous regular blocks, placed there as if by giant engineers of past ages, after being accurately sawn and planed. The top stone is without “bed.” From this are made setts, kerbs, channelings, edgings, and blocks for dock and bridge work. The next stone below has a real but almost imperceptible bed. From this stratum are produced flags, landings, steps, etc. Without the bed, this stone could not have been available for use for pavements, as owing to its extraordinary strength and texture, there is no machinery in existence that could cleave or dress it. The bed of the stone is absolutely horizontal, without the slightest deviation, and thus it is comparatively easy to produce flags with true natural faces. The flags will always present an unbroken surface under any conditions, because the stone is so strongly knit together that the “bed” which fortunately allows the stone to be split, never becomes exposed by wear.

Bitumen, or natural pitch, though limited for its commercial supply to a few districts, is nevertheless by no means of local or limited occurrence. Its origin is somewhat obscure, but it is probably the result of oxidation of the unsaturated hydrocarbons in petroleum. Its specific gravity is I '0924 and it is partially soluble in alcohol and more completely soluble in carbon bi-sulphide, petroleum spirit, chloroform, oil of turpentine, coal-tar, benzol and naphtha. Much of it is used for laying pavements, for damp-coursing, cellar or basement flooring, flat-roofing, bridge-building, and to stop vibration in engine foundations, culverts, tunnels and subways. Electricians find it the best and most effective insulator known. It is elastic, and is used in various circumstances where rigid cements fail, and wherever allowance has to be made for expansion and contraction. It is also employed in the manufacture of marine glue, and in its most highly refined state is made into wafers for fastening the tips on billiard cues. All the well-known asphalt firms employ bitumen for purposes for which their own rock asphalt is not so well suited, sometimes alone and sometimes mixed with asphalt rock or grit. Of late years bituminous sheets have been made, by running refined bitumen on to paper bagging, which are capable of being bent in any direction without cracking and yet can be perfectly joined and are impervious to moisture. This material is now very largely used as a damp-course, and also for lining ponds and tanks, for covering arches, and between the inner and outer rings of brick sewers. It is made in various thicknesses. A modification of this, consists of two layers of bitumen sandwiching a thin sheet of "laminated lead" between them. It is acid proof, and can be cut with a knife and bent in any direction; and is made in 6 ft. lengths and all standard breadths. An artificial rock asphalt is much used for street paving in the United States. This, it is claimed, is better than the natural rock, as the addition of the sand makes it less slippery.

Rock asphalt, used for carriage-ways in Europe, is a natural limestone impregnated with natural bitumen. The rock when quarried is of a chocolate colour, fine in grain, thoroughly and evenly impregnated with bitumen, varying from 6% of bitumen and 94% of pure limestone to 14% of bitumen and 86% of limestone. The following information explains the matter very fully: the method of obtaining this bituminous limestone or rock asphalt is by mining, and the seams are of varying thicknesses from very narrow streaks to 6 ft. and 10 ft. deep. It is found between two layers of white hard limestone either totally unimpregnated with bitumen or else with mere traces of it, which have the appearance of thin smoke or the faint stains in white marble. Sometimes, however, layers of sand and marl are found which have to be propped or held up by rubble.

3. Answer the questions:

1. What can you say about the method of quarrying limestone?
2. Can the detritus be crushed for road metal or burnt for lime?
3. Which stones are known as Mansfield?
4. Why is machinery not often employed during limestone quarrying?
5. What do you know about the Rutland group of limestone quarries?
6. What other groups of limestone quarries can you mention?
7. Where are sandstones worked?
8. Sandstones are all worked in open quarries, aren't they?
9. Which building material is used for carriage-ways in Europe?

PART II. TEXTS FOR INDEPENDENT TRANSLATING

Text 1. Composition of rock asphalts

At the company's works the rock is treated so as to be formed into *compressed asphalt* (or comprime) and *mastic,* the two forms in which it is used for the formation of roadways and pavements. For the purposes of the manufacture of the compressed asphalt the rock is received from the mines in blocks of irregular shape, which are first subjected to a crushing process in a steam crusher and broken to the size of walnuts. The material is then passed on to a machine called a disintegrator, which reduces it to powder. The powder issuing from the disintegrator is received on an inclined screen which allows the fine powder to drop through, while any grains too large for the meshes are carried over and conveyed back to the disintegrator to be reground. The powder thus obtained is deposited in a covered shed; when required for use it is heated in slowly- rotating cylinders over a fire of wood or coal until it reaches the right temperature for laying; this process takes two or three hours. The object of heating is twofold: 1) to evaporate moisture, 2) to bring the bitumen into such a condition that it may exert the maximum of binding power when subjected to compression by the rammers. If any portion is overheated the bitumen is fused; if underheated, the asphalt will not be thoroughly consolidated; hence the utmost care is needed in regulating the temperature, which varies for different kinds of asphalt, since some asphalts will bear a greater heat than others without deteriorating. The extreme limits are 250 to 300 degrees F. The mastic, which is supplied in blocks, known as Val de Traversor other mastic, is manufactured by pulverising the natural rock in exactly the same manner as for the compressed asphalt; it is then heated in boilers, and from 5 to 10%, of refined bitumen is added, and the whole mass reduced to a mastic or thick liquid state. This is run into moulds, and when cool again consolidates into a hard elastic block, which is used in varying proportions with grit and refined bitumen for laying pavements. In the laying of roadways with the comprime the method adopted is as follows: The roadway is formed with a bed of good Portland cement concrete, and evenly finished off to the precise contour of the roadway required. When this concrete has become thoroughly set, and become hard and dry, the powder, which has been previously cooked, is brought to the site whilst hot; and as asphalt in bulk retains the heat undiminished for several hours it can be easily conveyed in properly constructed carts from the cookers to the site, where it is spread and raked over to a uniform thickness, usually two-fifths to three-fifths more than the depth of asphalt prescribed for the finished road. The compression of the powder thus spread is effected by men with iron rammers, which have been previously heated in a fire to about the same temperature as the asphalt powder. After this has been accomplished and the mass reduced down to the finished thickness, the final smoothing is done by an iron instrument of curved form heated to an extent sufficient to soften the bitumen at the surface of the asphalt, and thus gives a fine finish and a glassy appearance to the whole. The work is then complete, and as soon as it is cooled to the temperature of the atmosphere the road can be thrown open to traffic. It can easily be seen that the whole operation of laying is one that calls for much specialskill and practical dexterity for its efficient performance. Roadways thus formed are very good, being nearly noiseless, cleanly, and impermeable to moisture. They also diminish to the utmost the force required for traction, and are durable; but constant traffic is necessary to keep the asphalt compacted, and it is consequently unsuited in this form for roofs, gutters, and many other building purposes. In the laying of the masticquite a different process is required. The mastic cakes, which are hexagonal, are manufactured at the works at Travers, and sent in this form to the site to be covered.These blocks are broken into pieces as big as a man’s fist, ready to be thrown when required into the heating apparatus in which the mastic is cooked. This apparatus, commonly called a street pot, consists of two parts. There is first the mantle, a round envelope of sheet iron furnished with a chimney and a small door opposite it for firing, the upper and lower rims being strengthened with iron bands; and this frame forms the furnace in which the fire is kindled. The second part is the kettle proper, a round pot of strong iron with a steel bottom, destined to receive the mastic; this pot hangs on the upper rim of the mantle by the flange, descending into the furnace for a little more than half its depth, but high enough to allow the flames of the fire to play all round it. The best fuel for heating the whole surface of the pot, thus giving uniformity to the melting, is peat or hardwood. Sometimes coke is used, but it should be avoided if possible, as it is apt to burn the bottom of the pot and thus tends also to burn the bottom mastic. Before lighting the fire a small piece of bitumen (half the required proportion) should be placed in the bottom of the pot, and, as soon as the fire has been lighted, the broken pieces of mastic placed on the top of it until the pot is a little more than half full; the cover should then be put over the top and the mastic allowed to stand for 20 minutes to half an hour, the fire being well kept up. During this time the materials should be watched, and as soon as the mastic commences to melt the cover should be removed and the mass stirred with a long stirrer. This stirring process finished, the remainder of the mastic should be put in, followed by half the remainder of the bitumen, filling the kettle to the top; again the cover should be put on and a steady fire kept up. When the mastic round the edges gives signs of melting it should be tirred constantly; when the whole mass has become pasty and soft, half the required proportion of fine sharp grit should be added with the remainder of the bitumen, spreading the grit evenly over the top. The proportion of grit should be varied according to the aspect of the street where the mastic has to be laid. Where it is exposed to the heat of the sun for any considerable portion of the day more grit and less bitumen should be used in mixing. It is an indication that the material is cooked when jets of blue-coloured smoke ascend from the surface; another and most frequent test is that of thrusting a stick into the mass, and if it comes out clean and the mastic does not adhere to it, the material may be consideredcooked. This cooking process takes from 4 to 6 hours. The material being ready for spreading, the mastic is taken out of the pot and put into a wooden pail, which is passed to the man who is termed the spreader, and he empties the contents with a sweeping motion across the path. He then spreads the material with a wooden float to the required thickness. It is essential in putting down this material that the second pailful should overlap the first whilst hot, and so on with each successive layer. If the surface on which the mastic is laid is at all damp, blisters will form in the mastic, and it is the business of the man who follows the spreader to prick them with a sharp piece of wood and rub the holes made until the blisters disappear. Sometimes he will also come across a burnt piece of mastic (caused by imperfect or insufficient stirring); this must be thrown out at once and hot mastic rubbed into the hole. It will be again noted that in this mastic a great deal depends upon the method of preparation and laying and the quality of the bitumen used, as any omission of care and skill will render the asphalt when laid inferior and not able to fulfil its purpose.

Coal-tar pitch is the residue of coal-tar after the separation of naphthas, phenols, creosote and anthracene oils. It amounts to about two-thirds the original weight of the coal-tar before distillation. Its character varies with 1) temperature of distillation; 2) quality of coal distilled. Coal-tar pitch may be either soft, hard or medium, according to quality of coal. The hardness depends greatly on the perfection to which distillation has been carried, and it is generally necessary to thin it down before use by addition of various tar oils. Only the heavy oils should be used, or the pitch will lose much of its binding or cementing power. It is obvious, therefore, that artificial pitch is not to be relied upon to the same extent as the natural product. It is, however, largely used for foot pavements to withstand moderate traffic, as the matrix of a kind of concrete, having coarse grit for an aggregate, and generally sprinkled over the surface either with marble chippings or crushed shells, the whole being laid hot and rolled with light rollers. This is commonly known as “ tar-paving”, though it is pitch, and not tar, which is used.

Text 2. Lime and lime-burning. some minor lime products

Lime, or quicklime, is a more or less impure oxide of calcium obtained byheating limestone, chalk, shells, coral, or any other substance composed almost entirely of calcium carbonate in such a position, generally in the open air, that the carbonic acid gas and any moisture which it contains are given off and escape. This operation is known as burning or calcining. The process of calcining is accomplished in kilns, of which there are two principal varieties. Pure chalk lime whose colour it is important to preserve is burnt in intermittent flare kilns in such a way that only the flame from the furnace reaches the stone, which is piled up above the fuel over rough limestone arches; but much more frequently tall, inverted, cone-shaped drawkilns are used, the fuel (coal) and stone being piled up in them in alternate layers and worked to a roughly formed cone on top. Such a kiln is generally built on a hillside, so that it can be filled from the top (which is quite open) and emptied from the draw-hole at the bottom when burnt through, the average time taken in burning being about a week. When the fire has burnt out and the lime is cool enough for handling, the furnace bars are removed and the contents of the kiln fall down to the draw-hole, whence they are at once carried in barrows into a shed to be either sold in lump or ground to powder. The lime generally used for mortar in the London district is the grey stone lime of the Surrey hills known as "grey" from the colour of the stone from which it is burnt, as after calcination it turns yellow. It is a mildly hydraulic lime, suitable for rapid work, which acquires a moderate degree of hardness in course of time. The grey stone underlies the white chalk lime, and both are burnt in flare kilns separately. The kilns are filled from a high level door at the back on the hillside, which is closed with rough stones as soon as they are full, and firing takes place from a low level in front. The fires are at first kept low so as not to crack the arches of raw stone directly over them; but as these stones become hot more small coal is shovelled on, and the fires kept burning briskly till the whole kilnful is well burnt, when they are allowed to cool gradually. The whole process occupies about 75 hours. The burnt lime is removed from low-level draw-holes at the side, and at once filled into trucks for removal, or ground. Well-burnt lumps should ring well. When tapped or hit Inverted Cone Shaped together; and those of Draw-Kiln, "stone lime" should be of a bright canary colour, the chalk lime remaining white. Pure quicklime has a great affinity for water, and is extremely caustic, rapidly burning up and entirely destroying any organic matter with which it may come in contact. It is consequently much used as a disinfectant, being freely sprinkled over or dug into the contents of old cesspools or midden pits if such are met with in building operations. If water be added to quicklime it "slakes" that is, it absorbs the water with effervescence, giving out heat, and, if in lump form, tumbles to a fine powder. The caustic properties have been lost and the substance converted into hydrate of lime, generally known as "slaked lime". Pure slaked lime, known as Rich Lime, has very little strength, and is mostly useful for whitewash and as a base for distemper. It will harden on the surface in course of time by absorbing CO_2 from the air, but if used in bulk or as mortar will remain soft underneath the hardened skin, and it has no cementing value. If the lime contain sand only, no improvement is effected other than would be obtained by the addition of sand. It is rendered more pervious to air, so that the hard skin is deeper. Such a lime is known as a Poor Lime, and is rarely burnt. Other impurities, however, notably clay and to a lesser extent magnesia and oxide of iron, affect lime most advantageously by their presence. They reduce the slaking action, rendering it slower at the same time; the extent to which the impurities are present being well indicated in this way. They also, according to the extent to which they are present, confer upon the lime the property of setting that is, of contemporaneously hardening and coagulating, cementing together substances with which it is in proximity. This action, especially in the less pure varieties, seems to be cumulative, increasing slowly for a very long and at present undetermined period of time, and in such cases is better displayed under water than in air. Limes which show these characteristics are called Hydraulic Limes either "Feebly", "Moderately", or "Eminently", according to the degree to which they appear. As a general rule limes burnt from chalk are only feebly hydraulic, and are suitable for plaster work only; those from ordinary limestone are moderately hydraulic; and those from stones of the lias formation are eminently hydraulic. There are "blue" and "white" lias limes, but the terms refer to the colour of the stone from which they are burnt, and not to that of the resulting lime.

ANALYSES OF TYPICAL STONE AND LIAS LIMES. When ground, blue lias lime averages eleven 3-bushel sacks to the ton. It will be found that two sacks of ground blue lias lime with the addition of sand (in proportion 1 to 2) will in the dry state measure roughly one cubic yard, and that one sack of lime with the addition of sand and ballast (in proportion 1 to 6) will, before water is added, measure about one cubic yard. Ground lime in bags should be kept in a dry place, and if not used within a short time (especially in damp or warm weather) the lime should be shot (under cover) to prevent its bursting the sacks.

Stones which burn naturally to cements are to be found to a large extent in some parts of the country, notably as rounded lumps of chalk which have been embedded for long periods in beds of clay, from which the once well-known Roman cement was made; but the product was so far inferior to the little less costly Portland cement, the process of manufacture of which will be explained in a later chapter, that it is scarcely, if ever, made now.The moderately and eminently hydraulic limes may be used in the ground-powder form hot, without slaking, and in any case should be used within a few days of mixing and before material setting commences; but lump lime and the purer limes must always be slaked.Care should be taken in slaking lump lime, and it is recommended that it be first broken into small pieces, then evenly sprinkled with water (preferably through the rose of a watering-can) and covered quickly with sand. It should be left in this state for at least 24 hours before being used. Any unslaked pieces may be put into the middle of the next heap to be slaked. No water should on any account be added after slaking has begun. It will be found that the proper quantity of water to be used in slaking is about a gallon and a half to every bushel of lump lime. Only so much lime should be slaked at one time as can be worked off, say, within a week or 10 days.

Selenitic lime is made by this same firm by calcining the lias rock from picked beds, which burn to a quick-setting natural cement, and grinding in raw gypsum with the calcined product, thus slowing down the setting power to within reasonable limits without any liability to slake. The resulting product will carry a large proportion of sand without serious loss of strength.

MINOR LIME PRODUCTS. Whitewash is a mixture of white quicklime and water. Any lime can be used so far as its efficacy is concerned, but where, as in the case of lias, the lime is slightly tinted, the whiter lumps are picked out for conversion into whitewash. The lime should be mixed up while "hot" with plenty of water, and applied at once with a large brush to the surface to be coated. The process, known as limewhiting, is exceedingly inexpensive, and is almost universally employed where, for sanitary reasons, frequent reapplication is desirable. Whitewash is by no means durable, as it rubs off easily, is washed away by rain, and does not adhere well to smooth surfaces. Constant renewal is therefore necessary, and it should not be used at all in exposed situations in its pure state. A moderately permanent whitewash for external use can, however, be made by thoroughly slaking lime in boiling water and adding sulphate of zinc and common salt.

Whiting is a name for powdered chalk which has not been calcined. To prepare it for use, 6 lbs. of this powder is covered with water for 6 hours, when it is mixed with 1Ib. of double size and left in a cool place to become like jelly, when it is ready to be diluted with water and used. It is commonly applied to plaster ceilings where better work than that obtained by lime-whiting is desired, the process being known as "whitening". It will not stand the weather. Thus to limewhite a ceiling is to coat it with whitewash, only one coat being possible; while to whiten a ceiling is to coat it with whiting and size, several coats being possible and two being usual.

Putty is made by mixing dried and finely-ground whiting, free from grit, with raw linseed oil. After being mixed it should be left for 12 hours, or it is made and sold in bulk, a small portion being taken and further kneaded up by hand as required. Where unusual adhesiveness is required, as in glazed fanlights with small lap, a little white-lead may be added to the putty with advantage; while a hard putty can be made by using turpentine instead of some of the oil; and an even harder putty by introducing white-lead, red-lead, and sand. These hard putties should, however, be painted soon after they are applied, as they are liable to crack. Soft putty is made by mixing of white-lead and gill of the best salad oil with every 10 Ibs. of whiting and the necessary linseed oil, the white-lead strengthening its adhesive properties, while the salad oil keeps it soft enough to prevent hardening, cracking, and consequent falling off. Much the same result is achieved by mixing tallow with putty, rendering it “thermo-plastic”, as it is called that is, sufficiently pliable not to be loosened by the expansion and contraction of glass in large sheets under different degrees of temperature. To soften old putty for the purpose of removing it, it is only necessary to apply heat in the form of a piece of heated metal, using it as a laundress uses an iron.

Text 3. Portland cement: its properties, constituents and tests

Portland cement, by far the most valuable of the lime products, is formed by drying, burning, and subsequently grinding to powder an artificial mixture of clay and chalk, or of shale and limestone. The resulting material, on the addition of water, has the property of setting, either in air or water, to rock-like hardness while at the same time binding or cementing together any materials with which it is in contact. It is also, when set, almost impervious to water. By means of recent microscopic investigations, four distinct mineral constituents, known as Alit, Belit, Celit, and Felit, exist in Portland cement clinker, and of these alit and celit are the most important; the clinker being a highly complicated solid solution of these substances formed by “sintering” that is, by diffusion at a temperature below that of the melting point. Perfect diffusion, by exposure to the proper heat for the right period of time, is essential for the production of good clinker; and this explains why clinker turns to dust which has not attained as high a temperature as that in the hottest part of the kiln. Beyond the latter degree of concentration he considers that the solutions or clinkers have not the structure of Portland cement, and cannot be regarded as such, although they are hydraulic. Setting begins to take place almost directly water is added. It is therefore essential that it should be used at once, only so much being mixed as is required immediately, for if cement be beaten up which has definitely begun to harden it loses a great part of its adhesiveness and cohesiveness, becoming little better than so much sand, and fit for nothing else than to be thrown away; for though these properties can be restored by reburning and regrinding, this is not economically practicable.

The period occupied in setting varies considerably; for though it is rarely less than one hour or more than 7, both quicker and slower setting cements can be made if required by varying the constituents and the manufacture slightly. As a rule this is not a matter of very great importance, except that the slower setting cements allow of greater latitude in mixing, and give time for any particles of free lime to be acted upon and slaked; but occasionally, especially in tidal work, quick setting is imperative, and in such a case the manufacturer should be informed and should not be tied to too rigid an analysis so long as other requisite qualities are not impaired. The correct test for setting is that of no perceptible impression being made by the point of a Vicat needle, this being allowed to rest lightly on the briquette, or on a mass of cement I ins. thick placed in a glass dish having a diameter of 3 ins.; setting being considered to have commenced when the needle no longer sinks to the bottom of the dish. Many users, however, employ the rough-and-ready test of thumb-nail pressure. Fresh cement, when first emptied from the casks or sacks in which it is sold, is generally "hot" that is, it slightly stings the bare hand or arm if plunged into it, or if a paste be made with water and the bulb of a thermometer inserted in the paste, a considerable rise of temperature will take place, up to as much as 12 Fahr. in an hour. Some rise is essential, for it shows that the necessary chemical changes which take place during setting are going on; but a rise of more than 6 indicates that the cement contains unburnt, or at any rate unslaked, particles of free lime whose presence may have very serious results. Hot cements will expand from this cause, sometimes at once, sometimes not till long after the work in which they have been used has been finished, and so are very particularly to be avoided, except occasionally in underpinning work, when a little expansion may be useful. A concrete upper floor has been known to expand and burst the building it was inserted in a year after completion. Hot cement should therefore always be cooled by being spread on a wooden floor under cover to a depth of not more than 12 ins., with a good current of air passing over it, and turned over occasionally, until the rise of temperature of a sample made into a paste with 20%, of its weight of water is not more than 6 Fahr. in an hour after mixing. Hotter cement than this is unfit either for use or testing. On the other hand, cold cement, which shows little or no rise of temperature, is inert and valueless, having lost its power of setting. Cement may become cold by too long exposure to air in too thin layers. Expansion may also be due to over-liming, and in this connection the following analyses of satisfactory material and product may be valuable. A first-class cement should not contain more than 125% of magnesia, 175% of sulphuric acid, 1% of carbon dioxide, or 15% of insoluble residue, nor more than 61 nor less than 56% of lime. These are severe demands, with which neither of the above analyses comply, though both cements are recognised as being good and reliable. Another great enemy to the soundness of a cement, though it quickens its setting properties, is the inclusion of any material proportion of underburnt clinker. This, which is bright yellow in colour, should be picked out during manufacture, and its presence is usually easily detected by the yellow colour of the cement powder, which ought to be a dull grey. An underburnt cement, too, has a low specific gravity. When properly cooled to a rise of temperature of 6 Fahr. in an hour after mixing, good cement should have a specific gravity of at least 308; but newly burnt cement is heavier, and should have a specific gravity of at least 3125. The test is rather a difficult one to apply, and should be done in oil, in a Schuman's or Keate's bottle; but it is at least reliable, which is more than can be said for any test of the mere weight of a measured sample. The great test for absolute soundness is that of boiling. A circular pat of neat cement, which it is essential shall be properly cooled, about J in. thick and 3 ins. in diameter, is made up on glass with 20%, of its weight of water. This is kept in moist air for 24 hours, and then immersed in cold water, which is raised slowly to boiling point and kept at that temperature for 3 hours. Under this test a bad cement will turn into soup, while an unsound one will crack from expansion or curl up at its edges from contraction. Only a thoroughly good cement will retain its form under this severe test, which requires great care, and should only be applied by an expert possessing the proper apparatus. Even the best cement, too, will not stand it if tested while "hot". The effect of boiling is to accelerate the changes which take place in a cement in use, expansion taking place in a few hours instead of several months. A modification of this test, which may be safely relied upon in most cases and used by the comparatively unskilled manipulator, can be made by means of an appliance like an incubator, in which the temperature is maintained within a degree or two by a cleverly arranged valve which regulates the supply to the gas burner. It also is based on the principle that moist heat accelerates the setting of cement, and that if judiciously applied, the age of several days may be artificially given to a cement in a few hours. A sound cement acquires great hardness in a short time when treated in this apparatus, but an unsound one, or one that would under ordinary conditions "blow" when used in work, is caused to develop this characteristic in a few hours; and hence, by use of this apparatus, a definite opinion may be formed as to whether a cement is a safe one to use or not; independently, of course, of its tensile strength, which may or may not be equal to that required. The apparatus consists of a covered vessel in which water is maintained at an even temperature of from 110 to 115, or even by some authorities up to 120 Fahr.; the space above the water is therefore filled with the vapour arising there from, and is at a temperature of about 100. Immediately the pat is gauged it should be placed on the rack in the upper part of the vessel, and in 5 or 6 hours it may be placed in the warm water and left therein for nineteen or twenty hours. If, at the end of that period, the pat is still fast to the glass, or shows no signs of blowing, the cement may be considered perfectly sound; should, however, any signs of blowing appear, the cement should be laid out in a thin layer for a day or two, and a second pat made and treated in the same manner, as the blowing tendency may only be due to the extreme newness of the cement. A tendency to "blow", or expand after setting is often caused by the inclusion of coarse particles in the cement, which contain free lime within them. Such particles have little strength or cementing value, and their presence is therefore highly undesirable, especially as it is exceedingly difficult, by the ordinary process of air-slaking which cools the finer particles of free lime and renders them innocuous, to similarly get at the lime concealed in a metamorphic condition in coarse lumps of hard cement. Fine grinding is therefore essential for safety, and it has the added advantage of putting the cement into a condition in which its quality of adhesion can be most highly developed, giving it great "covering" power, and enabling it to penetrate the tiniest crevices; and this even though extremely fine grinding reduces its cohesion. All good cement is now reduced to an impalpable powder. It is extremely important that testing sieves should be uniform, with the mesh of standard wire whose diameter is equal to half the breadth of the hole. The diameter of wire for all the ordinary sieves is given in the last column of the above Table; but much finer sieves, with correspondingly finer wire, are occa- sionally made and used, down to one with 36,000 holes per square inch. A very high resistance to tension, or power of cohesion, is not necessarily an advantage, as it may be due to the cement being "hot" or to its containing an excess of lime; but it is a highly valuable quality in a finely ground and properly cooled cement which will stand successfully the boiling or the incubator test. Most manufacturers will undertake to supply much stronger cement than this, but in the majority of building works excessive tensile strength is by no means so important as absence of expansion, cracking and shrinkage. For the purpose of testing cohesion, the neat and properly cooled cement is mixed with 20%, of its weight of water, or the cement and sand with 10%, of water, and pressed into iron moulds, having a sectional area of one square inch at the narrowest part, where fracture will occur. Thumb pressure only should be used, as any artificial pressure or ramming will result in a much higher resistance; and as the thumb pressure of different individuals varies, it is best that any series of tests should be conducted if possible by the same person and under similar conditions. The briquette thus made should be kept in a moist atmosphere at a temperature of at least 50 Fahr. for 24 hours, and then should be removed from the mould and placed in water at not less than 55 nor more than 60 until the period at which the test is to be applied. The briquette is then inserted in the clips of a testing machine, of which there are many patterns. Strain is gradually applied, at the rate of about 400 Ibs. per minute, by turning the handle, the amount being shown upon the dial, which has two hands, one of which is loose and remains to record the breaking strain, while the other flies back to zero when the tension is released by the snapping of the briquette. Great care must be taken that the briquette is put in truly and evenly, else the pull will be unequal and the fracture be diagonal instead of straight. The following results bear out the generally received opinion that cement should be used as soon as possible after being mixed, the delay of only one hour producing very seriousdeterioration. The experiments were made upon briquettes composed of 2 parts of sand to 1 of cement, mixed with 10% of water.Ultimate tensile stress after two months.

It is also worth noticing that a highly aluminous cement which, after plastering, will set in an hour, has often been found to set in three minutes when stored in closed freight cars for some time in a hot summer's sun.

Text 4. Portland cement: its manufacture

There are at present three principal methods employed for the manufacture of Portland Cement. Though probably no two firms work on exactly the same systems, these may be considered as typical of what, for want of better names, may be termed the “Ordinary”, and the “Semi-Dry”, and the “Rotary” processes respectively. The clay and the chalk are raw materials, which naturally vary somewhat, are constantly analysed, and the proportions in which they are mixed are altered from day to day accordingly. The chalk and the clay are filled into banows of different sizes, and each barrowful is weighed and then tipped into a circular pit with ample water in it, about three of chalk to one of clay. The pit has a vertical axle carrying arms like wind-mill sails, only with blade attachments in place of sails, and these being given a rotary motion, beat up the contents of the pit into a creamy liquid, which is driven out through a grating. The “slurry”, as this mixture is called, is next passed between horizontal grindstones, like those used for grinding corn, which reduce it to such a degree of fineness that all will pass through a sieve of 2,500 holes per square inch, and only 5%, be retained on a 32,ooo-hole mesh. At one time the slurry was run into large open-air “backs”, or shallow reservoirs, to settle, but this has now been entirely abandoned in favour of artificial drying by the aid of the spare heat from the kilns. The hot air passes over the slurry, of which the drying chamber contains just enough with which to charge the kiln, then down through holes in its iron floor, circulating between dwarf walls as shown by the arrows on plan, and thence to a long continuous flue the entry to which is controlled by a damper. This flue serves for a long range of kilns, and leads to a large central chimney. The dried slurry, now known as “slip”, is filled into the kiln, mixed with small coal to act as fuel, the kiln being piled right up to its arched roof. As soon as it is full, and the drying chamber empty, a rough wall of slip is built round the kiln edge, and a fresh charge of slurry is pumped on to the floor of the chamber. All openings are then bricked up with fire-bricks set in slurry, except a small hole in the fuel door left for purposes of inspection which is temporarily closed with a dry brick, and the kiln is fired from beneath, as much air as possible being allowed to get to it through the fire-bars.An intense heat is generated, and it takes about a week to burn through a kiln, and to convert a chamberful of slurry into slip. At the end of that time the kiln is allowed to cool down, and it is found that its contents have been reduced to one-half their former bulk, and have been converted into a hard metallic clinker of honeycomb structure. The fire-bars are now removed and the clinker falls into the draw-hole. It is there filled into barrows, any yellow (underburnt) lumps being put on one side to be passed through the kiln again, while the good clinker is taken to powerful grinding mills. This final product is again tested, by all the principal analytical and mechanical tests, and a check thus kept upon the working from start to finish. Ball and tube mills are generally used for grinding, the clinker being fed through a hopper to the ball mills, passing out as a powder, which goes through the tube mills afterwards to reduce it to the impalpable condition in which it is sent to market. The Ball-mills are large hollow cylinders containing a number of steel balls which grind against one another as the horizontally placed cylinders revolve on their axes; while the Tube-mills long steel tubes set to a slight incline are half full of flint pebbles, which in a similar manner rub against one another, grinding the clinker and powder as the tubes revolve.

The "Semi-dry Process" differs only from the above so far as is necessitated by the raw materials being hard instead of soft; blue lias limestone taking the place of chalk, and a hard shale that of the clay. Crushing is consequently the first operation, and then grinding under an edge runner so as to pass through a J in. mesh formed in the pan of the mill. Mixture then takes place with only a little water, so as to pass the ingredients between horizontal grindstones, producing a dark-coloured slurry of about the consistency of porridge. This is pumped on to the drying floors of Johnson kilns,and the subsequent treatment is exactly similar to that already described, except that the heated air from the kiln, after passing over the contents of the drying chamber, is carried under iron plates on which is spread a thin layer of slurry. When a kilnful of slip has been heated through and collapsed, slip from this supplementary drying chamber is introduced to fill it up again, without any more fuel; and as this burns in the heated kiln just as thoroughly as does that which is first inserted, a distinct economy is effected. At the Swanscombe works of the Associated Portland Cement Manufacturers, Limited, the slurry, after being mixed in small pug-mills or "wash-mills", and ground between French Burr-stones, is pumped into a mechanical sieve, consisting of a circular basin in which beaters or fans revolve at considerable speed, throwing the liquid forcibly against an inclined sieve of 1,225 holes per square inch. Any materially coarse particles are thus retained, while what passes through would leave a residue of but 5% on a 32,000 mesh. This sifted product, little denser than milk, is collected in an external annular trough and passes in a continuous stream through a large pipe to one of several great mixing tanks, each capable of holding 1,200 tons of slurry. These also are circular, with massive beaters slowly revolving in them to thoroughly incorporate the contents and prevent settlement. The effect of this complete mixing of large quantities of slurry is the production of a cement of almost uniform analysis, the variations which inevitably occur in mixture in small amounts being compensated when mixture takes place in bulk. In this short space of time the moisture has been evaporated from the slurry, passing up the chimney as steam, and the "slip" thus produced has been rendered bone-dry aboutthe middle of the kiln and burnt to clinker at the lower end. The rotary motion, throwing the slurry into drops and the slip into small lumps, greatly facilitates the burning, which can be rapid as well as thorough, the small pieces becoming quickly and completely calcined. The burnt clinker, which is entirely free from dust, falls over the edge of the kiln at the lower end B, as it rotates, into a hopper, and passes thence into another long revolving cylinder through which a current of cold air passes and thence to another similar cylinder in the same way. These cooling cylinders are rifled with deep grooves throughout their length, so that as they revolve the lumps of clinker are caught and dropped, to assist in cooling them; while the air which enters at the lower end of the cooling cylinders, having been gradually warmed as it passes over the hot clinker, is then introduced into the kiln though the way in which this is done is not shown on the accompanying diagram. The Cement Clinker is subsequently ground in the usual way by means of Ball and Tube Mills.

Text 5. Mortar fire cement

Mortar is the substance used for filling up the interstices between the blocks of solid material of which a wall is built, forming at the same time a soft and level bed for the blocks to lie upon, so distributing the load evenly over the surface of the lower blocks, and to a greater or less extent cementing the blocks together so as to form one homogeneous whole. It is generally composed of lime and sand, or of substitutes for these materials, in varying proportions, roughly gauged by bulk, so that the matrix (lime or cement) may just fill up the natural interstices between the particles of the aggregate (sand). Pure and poor limes should not be used.

Lime mortar should be used where shattering or swaying motion has to be resisted, as in tall chimney stacks and church spires, a certain amount of "play" being advisable under such circumstances; but for rigid resistance there is nothing to equal cement. Thin walls, such as half-brick partitions, should also be built in cement mortar, although lias lime mortar is admissible if they are not more than about 9 ft. high and are supported by cross-walls pretty frequently. Careful mixing of the ingredients of mortar is quite as important as the use of proper proportions.

Ground lime should be used in the proportion of 1 bushel of lime to 2 or 3 bushels of clean, sharp sand, free from dirt or loam. This should be first thoroughly mixed in its dry state, which may be done by turning them over together several times with a shovel, and afterwards, to ensure a more perfect mixture, passing the whole through a riddle. After this has been done the mixture should be left in a heap for a day or two. Mortar may then be made from the heap as required by the addition of water, and a further mixing in the wet state.

When *lump lime* is used instead of ground, special attention should be given to the instructions for slaking, and the slaked lime and sand should be passed together through a riddle. The amount of water required for mixing mortar will depend on the quantities and nature of the materials used, but in the above mixture (1 to 3 of sand) it would be from ij to 2 gallons per bushel of lime and sand. This is in addition to that used in slaking the lime. Much more perfect incorporation is secured by the use of a mortar mill, and as it is more economical to employ one than to mix by hand on even a moderate scale, it is generally used, especially where power is available. There are two types those which are self-delivering, these being most suitable for hard, rough grinding; and those which have revolving pans passing beneath edge runners. Of these the latter is in more general use. There is a false bottom-plate of hard iron to thepan, which can be renewed when it wears away from contact with the heavy metal rollers. Either Lump or Ground Lime can be used, and the mortar may be made in proportion of 1 part lime to 3 or 4 parts sand. The sand must be thoroughly clean and sharp, and where this is not readily obtainable, excellent results may be had by substituting good old broken bricks (clean and well burnt), well burnt ballast, stone chippings, furnace cinders or slag. It is most essential in all cases that the materials used should be perfectly clean and free from loam, clay, or other impurities. The mortar should be left in the mill until thoroughly reduced and incorporated, but excessive grinding is detrimental. When Lump Lime is used, it should, for the sake of economy of time and power, be wholly or partially slaked before being put into the mill; and if this, either from want of space or otherwise, is not found convenient, ground lime should be used in preference, as the small extra cost is in most cases more than compensated for by the greater con- venience in handling, and the saving of labour and room required in slaking. If unslaked lime be passed direct into the mortar mill, more water and mixing will be required, and the mortar should stand for a few hours to allow the lime to slake. Mortar made with *selentic lime* has to be treated in an entirely different manner. If prepared in a mortar mill, pour into the pan of the edge runner two full-sized pails of water, then gradually add one bushel of selenitic lime, and grind to the consistency of a creamy paste, then throw into the pan 4 or 5 bushels of clean, sharp sand, burnt-clay ballast, or broken bricks, which must be well ground until thoroughly incorporated. If necessary, water can be added to this in grinding, which is preferable to adding an excess of water to the prepared lime before adding the sand. The water and the selenitic lime must be mixed together first, and, if Self-discharging mortar mills be used, the lime and water are preferably mixed in a tub, as explained hereunder, adding the paste to the sandproportionately as required in the mortar mill. Where there is no mortar mill, an ordinary tub or trough (containing about 40 or 50 gallons), with outlet or sluice, may be substituted. In this case, pour into the tub six full-sized pails of water, and gradually add a 3-bushel sack of selenitic lime, which must be kept well stirred till thoroughly mixed with the water to the consistency of a creamy paste. Form a ring with half a yard of clean sharp sand, into which pour the mixture from the tub. This should be turned over 3 or 4 times, and well mixed with the larry or mortar hook, adding water as necessary. One 3-bushel sack of selenitic lime requires about 18 gallons of water. There are 12 sacks to the ton.

Cement mortar needs still different treatment. It should not be mixed in a mortar mill because of the great risk run of grinding being prolonged after setting has commenced. The ingredients should first be mixed dry in a small heap, being turnedover at least twice. Just sufficient water (about 15%) should then be added through the rose of a watering can, the mixture turned over once again and used immediately at any rate, within half an hour of mixing, and much sooner than this if the cement be quick setting. Neat cement is generally mixed with just enough water on his palette by the bricklayer himself only a few minutes before it is needed. The bulk of mortar is about 25%, less than that of the ingredients of which it is composed when separate and in their dry state. This is due to the interstices between the grains of sand being filled with the lime or cement and water, which are almost, and sometimes entirely, absorbed in this way. Once mixed, all mortar should be placed in a tub or on a wooden platform to keep it clean until required for use. Only so much should be mixed at one time as can be used before it commences to set, and any which has begun to stiffen should be rejected. Unfortunately it is easy to throw into a mortar mill any which has been exposed through a night and has thus begun to set, and to mix it up with a little fresh lime and use it, and a good deal of indifferent work is traceable to this cause. Moisture assists the setting action of all hydraulic limes and cements, while if deprived of its moisture before setting has taken place a mortar will revert to its original constituents and become mere inert sand. Consequently in hot weather all brick or stone used in building should be well soaked, else the moisture will be rapidly drawn from the mortar into the thirsty bricks, and setting will not take place this being more apparent in mortars made with slow setting limes than in those made with the quicker setting cements. In all cases work executed in damp earth or under still water becomes eventually harder than that done in air. Frost also rapidly destroys unset or partially set mortar. In frosty weather work must either be stopped or executed in a cement mortar which will set more quickly than it will freeze. Mortar should be used of as stiff a consistency as possible, all beds being even, all surfaces covered, and all joints flushed up that is, in walling. A liquid mortar, known as *grout*, is often poured over the surface of a brick floor and swept over it with a broom so as to penetrate every crevice, but it should not be employed in walling; for, though excessively rapid work can be done by laying a thick bed of soft mortar and running the bricks along it into place, the practice is far from commendable.

Fire cement. Where mortar has to be employed in a position where considerable heat has to be withstood, either raw fire-clay should be used, or a fire-resisting cement known as “purimachos” may be employed. Its composition is a secret, but its qualities are unquestionable. The following particulars are taken from the manufacturer's circular.The word "cement" means the moist paste; the word "powder" means the dry powder; the word "wash" means the moist paste or cement reduced with clean water to the consistency of whitewash.

Cement (Moist). The white and dark cements are equally efficacious as fire-resisting materials. The white is generally used for glazing and for other purposes where the colour of the work or surroundings have to be matched. The dark is generally used for general repairs, it being lighter in weight. The cement is sent out ready for use, and may be used for most purposes for which fire-clay is employed. It should, as a rule, be applied in the same manner in the consistency of newly tempered mortar. If too stiff, add a little clean water; for resisting great heat, add powder well mixed together. The cement is not intended to be brought in contact with lime, chemicals, fluxes, etc.

Powder (Dry). The powder is not cement in a dry state, which can be converted into plastic cement by wetting it; it is an entirely different composition, and is not to be used by itself. It is prepared for combining with cement in cases of great heat; to impart to it greater body; or to cause it to set more quickly when cold. For moderate heats i.e., not exceeding 1 200 Fahr. (as in open fire-grates, or in pointing round kitchen ranges, etc.) the cement should be used by itself. For very high temperatures the best results will be obtained by the admixture of a sufficient quantity of powder (failing it, sifted fire-clay); and, as a rule, the greater the intensity of heat to be encountered, the greater should be the proportion of powder (say 1 to 3 parts or more of powder to 1 of cement).

Mixing. The best method of perfectly and readily mixing together the cement and powder is this: In a clean bucket, reduce the required quantity of cement to a batter or wash, to which add gradually the proper proportion of powder. With a trowel work up the whole thoroughly well to the consistency of newly tempered mortar. It is absolutely essential that the cement should be first reduced to a batter or wash as described above; and then after this batter has been made up, powder may be added slowly and by degrees and thoroughly well mixed in and completely blended evenly throughout the whole mass. The mixing, if done in any other way, may produce failure and disappointment. Do not mix more than is required for immediate use. Before applying Purimachos, remove all dirt, dust, grease, grit, carbon, rust, or loose pieces, so that the cement may adhere to a firm surface, and not to any loose substances. Iron surfaces should be similarly cleaned; and, where upright or sloping surfaces have to be covered with a layer of Purimachos, it is desirable to roughen the metal with an old file, bent to a suitable shape to act as a scraper. Then apply a wash with a clean brush, and let it dry. Upon this a layer may be applied to the required thickness, and thus get a better grip of the iron. Joints in brickwork should be made very narrow with Purimachos. In jointing cracks, work it well in do not merely plaster it outside. In cases of large fissures, etc., and where there is a difficulty in keeping it from falling out as in the arches of furnaces, etc., support it in position until heat is applied, when the whole mass will set quickly with a slight expansion. Wooden supports may be used and allowed to burn away. Purimachos may be applied to a cool or hot surface ; but it is desirable to apply it whilst cool. To ensure a perfect finish, plaster with Purimachos should be as thin as possible.

Text 6. Lime plaster, plaster of paris

Ordinary plaster is, like mortar, composed of lime and sand, the principal difference between the two materials consisting in the lime for plaster being "pure" or non- hydraulic. No powerful cementitious quality is required, so long as it will adhere to a rough surface and can itself be brought, by the application of successive coats each finer than the last, to a smooth and level surface. On the other hand, it is generally required to be porous and absorptive of moisture contained in the air, which otherwise would condense upon the plastered surface and run down it in unsightly streaks. The lime used must be thoroughly slaked, so that it shall not "blow" (or blister) after being used. A ring of sand is usually made, and the lime well slaked within this ring and left covered with water, the sand being presently mixed with it and the whole heap again left for some weeks to weather before use. There is rather more sand than lime and the mixture is known as *coarse stuff.* When it has to be used on laths, whichthemselves are comparatively smooth while they have spaces between them into which the plaster is squeezed, ox hair should be mixed with the coarse stuff, in the proportion of about i Ib. of hair to every 2 cubic feet of stuff. The hair should be long, free from grease, and well separated, preferably by immersion in water, and is best incorporated by hand with a rake. If a mortar mill is used the hair should be added at the last minute and the grinding only continued long enough to ensure mixing, as if it is prolonged the hair is broken into short lengths and rendered valueless. This, the first coat, is called "rendering" if on brickwork, and "plastering" or "pricking up" if on laths. The second coat, known as "floating", may also be of coarse stuff, but there is in no case any necessity for it to contain hair. The third, or finishing coat is much thinner than the first or the second and, if it is to be papered, consists of *fine stuff*. This is pure lime which, after slaking with a little water, has been mixed with much, allowed to settle and the surplus water drawn off. The stodgy mass which remains, kept preferably in a large tub, is still left for the contained water to evaporate and the lime to thoroughly cool until it is wanted for use.

If the finishing coat is to be whitened or coloured with distemper of any kind, it should be made of *plasterer's putty,* which is almost identical with fine stuff, only more carefully made, run through a fine sieve, and kept from dirt. For making good defects, and sometimes as a superior finishing coat, *gauged stuff* is used, this being made by mixing plaster of Paris with plasterer's putty.

Generally the proportion of plaster of Paris is about one-fifth of the whole, as a larger proportion may cause cracks to appear in the finished work; but gauged stuff is also used for running cornices and other ornamental work, when the proportion of plaster of Paris is increased to as much as 50%, of the whole. The addition of this substance greatly hastens the setting (or hardening), so that only very little may be mixed at one time. Selenitic lime can be used in place of pure lime for coarse stuff, it being made, where it is to be employed for rendering, exactly as is selenitic mortar. If for use as a first coat of plastering on laths, however, 9 bushels of sharp sand are added to a mixture, fresh made, of 3 bushels of selenitic lime in 18 gallons of water, and then 3 hods of well-haired fine stuff mixed in. For the second coat the 12 bushels of sand would be used and the hair omitted from the putty. If a hard face is required, prepared selenitic lime may be first passed through a 24 by 24 mesh sieve, to avoid the possibility of blistering, and used in the following proportion: 4 pails of water; 2 bushels of prepared selenitic lime; 2 hods of chalk lime putty; 3 bushels of fine washed sand. This should be treated as trowelled stucco, first well hand-floating the surface and then well trowelling. A smooth and even harder face, if well hand-floated and then well trowelled, is produced by the following mixture: 5 pails of water; 1 bushel prepared selenitic lime; 1 bushel prepared selenitic clay; 2 bushels fine washed sand; 1 hod of chalk lime putty. It is suitable for the walls of hospital wards and public buildings, and, being non-absorbent, it is readily washed.

Plaster of Paris is obtained by partially calcining or "boiling" *gypsum* (hydrous sulphate of lime), otherwise known as *selenite*, so that it parts with most of its contained water. It is mostly used in building operations for small castings applied as enrichments to plaster decorations, its property of slightly expanding while setting making it capable of taking extremely sharp impressions. It is, however, soluble in water, and so can only be used in dry internal situations. It is also occasionally employed as a cement. It does not effervesce when treated with acid, and it sets with great rapidity. The best plaster of Paris, setting quickly and hard, is made by the plasterers themselves from the raw stone. This is ground and spread in a layer some 2 or 3 ins. deep in a shallow metal dish over a fire. When the temperature approaches that of boiling water the surface appears to rise up bodily as if suspended by the aqueous vapour given off by the lower layers; little craters are formed all over the surface and steam passes off freely mingled with fine dust ; and the plaster is stirred from time to time till no further evolution of moisture takes place, as tested by holding a cold plate over it to condense the steam, when the heat is withdrawn and the plaster is ready for use.

Sirapite is a species of plaster of Paris similarly made from gypsum impregnated with petroleum. It is now largely used either in addition to or in place of chalk lime for ordinary plaster work, being easy to work and rapid in setting, so that a room can be rendered one day and finished the next, while the resulting surface is hard and smooth, with no risk of bubbles forming. It should be mixed in small quantities at a time, and should not be used upon permanently damp walls, such as retaining walls and basement walls where there is no efficient damp-course. It will keep some time in a perfectly dry store; but it is better to use it fresh from the works. If it has been kept, or the age is unknown, it should be tested before using in bulk. The work should be thoroughly dry before being decorated upon. The following are the makers' directions for using Sirapite plaster.To be mixed in a banker like ordinary cement. For first coat on walls, one measure of Sirapite to 2 or 3 of good clean sand. For first coat on lathwork,two measures of Sirapite to one of good clean sand. Any laths will do, but for economy of material, sawn laths nailed J in. apart are preferable. Finish to be applied neat as soon as the first coat is sufficiently firm. Many users mix the finish in a pail. A small proportion of well-run lime putty may be mixed with the first coat. The lime must be properly burned and thoroughly slacked. One ton of coarse Sirapite and 5 cwts. of finish will cover from 125 to 130 yards super f of an inch thick finished. On metal lathing, for the first coat, Sirapite plaster should be mixed half and half with common hair plaster, the finish to be applied in the usual way. Where the suction is great, as on stone walls, Sirapite plaster should be applied half and half with common wall plaster and finished with Sirapite finish in the usual way. The face of the wall should be scored and quite clean. It may also be necessary to size the face before applying the plaster. Many users utilise Sirapite plaster for gauging common lime plaster. Used in this way the latter is so much improved that it becomes equal in most respects to the most expansive hard plasters. It makes excellent and rapid work, is fat and easy to use; and can be finished in two coats. For walls, use Sirapite plaster half and half with common wall plaster. For ceilings, use Sirapite plaster half and half with common lime and hair plaster. Finishing may be in neat Sirapite finish, or the same mixed with more or less lime putty.

Keene's, Martin's, and Parian cement are all hardened forms of plaster of Paris, of great use where an impervious, hard and smooth surface is required, and in skirtings, dadoes and angle staves likely to be subject to rough usage. Keene's Cement is made by steeping the calcined stone (gypsum) in a strong solution of borax and cream of tartar. The liquor is composed of 1 part of borax and 1 part of cream of tartar, dissolved in about 18 parts of water. In this solution the plaster in the lump, as withdrawn from the oven, is allowed to remain till it is thoroughly impregnated with the salts, when it is taken out, dried, and reburnt at a dull red heat for about six or eight hours. When cool it is ground to a fine powder and is then ready for use. In making Martin's Cement the solution used is one of carbonate of potash, while for Parian Cement an intimate mixture of powered gypsum and dried borax is calcined and then ground to a fine powder.

Gypo is a new plaster, the method of manufacture of which has not been divulged, and for which it is claimed that it is more than ordinarily fire-resisting; that it adheres firmly to iron and other metals, no key being required; and that it may be painted or distempered within 48 hours.

An asbestos non-conducting composition is made for plastering heated surfaces, the following being the maker's directions respecting it:

1. For all surfaces of steam pipes, boilers, etc., which are to be free from grease. Surfaces must be covered when hot. Add to the dry compo sufficient water to make it into a good mortar, and apply the first coat very thin to the heated surface with the hand. When dry, other coats should be applied by the hand about half an inch in thickness, the last coat should be levelled and finished off with trowel; when dry, the covering may be painted, or tarred if exposed to the elements.

2. For boiler and steam pipes. May be used as a covering for other boiler-covering compositions that need repair, or as a finishing coat over old asbestos compo, to which it imparts a very hard and smooth surface. Mix in a pail to a fairly thick paste, and empty on covering, smoothing off with a trowel; it cannot be remixed with water after once setting.

3. For gas and water mains, gas purifiers, tanks, stills, or constructional ironwork of any kind, where the temperature does not exceed 150 Fahr., to be applied direct to the surface of metal. No key, netting, or wrapping needed. Mix in equal proportions with sand, in small quantities at a time, for immediate use, as it cannot be reworked with water after once setting. May be painted or tarred if exposed to the elements. Plastering used externally is generally known as "*stucco"* if smooth, and as "*rough cast*" or *"pebble*", "*dash*" if rough. Of these, stucco generally consists of 1 part of hydraulic lime to 3 of sand, trowelled to a smooth surface. If it is to be used as an external protective coat to a wall which is likely to be exposed to driving rain, it is frequently in two coats, of which the first is made with Portland cement instead of lime. Rough cast is made, as a rule, in the same way as stucco, coarse grit being used in place of sand, and the surface being gone over with felt after being trowelled, so as to bring out the grit and roughen it; but an almost better effect is obtained by first rendering with hydraulic plaster, then covering this with a very thin coating of neat Portland cement, and immediately dashing on to this a mixture of grit and coloured lime, with a motion similar to that used when sowing corn by hand. The term "stucco" is, however, also applied to any smooth plaster, carefully worked up, in order that it may be painted on. Perhaps the smoothest and most perfect stucco ever made was that used in the old buildings of Ceylon, in which white of egg formed a principal ingredient; but its composition and method of working are not absolutely known. Plaster is suitable for application in a thin layer on a firm backing, may be brought to a smooth surface over a large area. The backing should be rough, in order that the plaster may adhere to it. A backing of lathing

on timber is liable to shrink and warp, causing unsightly cracks in the superimposed plaster. Lathing, whether of wood or metal, is too smooth for plaster to adhere to it. Spaces have to be left, and the plaster pressed into the spaces, preferably mixed with hair to assist it to cling. Each coat should partially dry before the next is applied, and all should thoroughly dry before it is papered or coloured. Only hard-surface plasters, such as Keene's or Parian cement, should be used in skirtings, angle staves, and other positions liable to wear. Mouldings can be " run", but undercutting must be avoided, as should also excessively variable thickness of the plaster. Enrichments can be cast, and by attaching the castings to both sides of a hollow moulding the effect of deep undercutting is easily obtained. Shallow trowel-formed and stamped ornament is also possible, while large enrichments can be built up by a clever modeller, but cutting is impossible.

Text 7. Concrete

Any mixture of substances such as will within a reasonable time harden into a compact mass may reasonably be called concrete, but the term is generally restricted in use to a combination of some inert aggregate, such as pebbles, broken stone or brick, with a cementitious matrix such as lime or cement. Such a material, according to its constituents and the proportions in which they have been employed, is useful for foundations, walling, damp-resisting floors, lintols, and as a filling between steel framework in fire-resisting floors, and in flat and domed roofs. For ordinary foundations, where there is no excessive weight to carry, Lime Concrete may be used, and a suitable mixture is as follows: 1 part of ground stone or lias lime, 1 part clean sharp sand, and 4 to 5 parts broken stone, bricks, or well burnt ballast, small shingle, or slag. If unscreened Thames ballast be used, care should be taken to see that the proportion of sand in it does not exceed that of the lime. The ingredients should be very thoroughly mixed dry, and again when water is added, which should be through the rose of a watering-can or hose, in just sufficient quantity to penetrate but not to saturate the mass. Concrete may be made with selenitic mortar as a matrix, by using 6 full-sized pails of water, 3 bushels of selenitic lime, and 3 bushels of clean sand. These ingredients should be mixed as before in the edge runner or tub, and then incorporated with from 15 to 18 bushels of broken stone or bricks or burnt ballast, the whole being turned over 2 or 3 times on the gauging floor to ensure thorough mixing with the ballast. When the tub is used the sand must be first mixed dry with the ballast, and the lime poured into it from the tub, and thoroughly mixed on the gauging floor. An addition of one-sixth of Portland cement will be found to quicken the setting. It is of the utmost importance that the mode here indicated of preparing the concrete should be observed, first well stirring the selenitic lime in the water before mixing it with the sand, ballast, or other ingredient, as otherwise the cement will heat and be injured. Where strong foundations are required, and in almost all other cases, it is essential to use Portland Cement Concrete to ensure good work. One part, by bulk, of cement is mixed with six of aggregate, these substances being twice turned over with spades while heaped upon a clean platform of boards, sprinkled with water through a rose, and again twice turned over. Where large works are in progress it has been found both more economical and more satisfactory in result to employ mixing machines, of which there are many kinds upon the market.

The aggregate is first shovelled or tipped into the elevator-box A, which is of a size suitable for one charge, and the measured quantity of cement added. The attendant, by pressing a lever, causes the elevator-box to rise in the slides B,B, and discharge its contents into the feeding-hopper C, which in turn passes it into the drum D. This is caused to rotate, and as it contains a central shaft to which blades or paddles are attached, the materials within are intimately mixed. After dry mixing in this way for a sufficient time, water, in an amount which can be exactly regulated, is admitted to the drum from the cistern E, and the mixing is continued. When this is complete, the contents of the drum are discharged into a tipping-waggon F, which runs upon rails below it, or into a barrow. Concrete should not, however, at any time be thrown or dropped into position from a height, as this tends to separate the materials, the heavier particles falling to the bottom; but it should be rapidly wheeled to the site after mixing, carefully lowered into position, and spread in layers. Ramming has, to some extent, the same effect as dumping from a height, and although it is often advocated as tending to make the substance homogeneous, it ought not to be necessary if the materials have been properly proportioned and enough, but not too much, water added. Concrete can also be cast in moulds for many purposes, such as window sills and lintols, being then made with small aggregate and often kept under slight pressure until setting is complete. Many artificial stones, largely advertised and sold under high-sounding names, are nothing else than cement concretes. Cement concrete should be used at once, but lime concrete may be left for a short time before being used to ensure the slaking of all the lime. It is desirable that concrete for foundations should not be built upon until it has been allowed to set for at least seven days. Where more concrete is to be deposited on any concrete face that has become dry, such surface should be thoroughly cleaned and well wetted previous to the application of the new material. One of the great practical difficulties which is met with upon public works is getting concreters to mix materials in small quantities just sufficient for immediate use. If large volumes are mixed at one time they can only be prevented from setting by the addition of excessive quantities of water, and this will have a most harmful effect upon the work for all time, as proper crystallization will never take place. If small quantities are used and mixed with just enough water to make them plastic and workable, a first-class concrete is obtained. It should be remembered that chemical action begins with a cement as soon as water is added, and this action is not delayed by the addition of sand or other aggregate. It follows, therefore, that cement concrete which has partially set should be thrown upon one side.

Another matter which needs careful attention is the protection of concrete from frost, and from sun and wind when initial setting is in progress, as bad effects are caused by the sun as by frost; the latter expands the materials, and so disintegrates them, and the former robs the mixture of the water requisite for crystallization. Work carried out under conditions of extreme cold should be protected by sacking, and the water used should be warm; or if the work is in the nature of paving, an inch of sand spread over the surface will effectually prevent any but excessive frosts from disturbing the concrete. In the case of heat, it is a great advantage to keep the face of work watered and to cover it up with damp sacking. A properly proportioned concrete should be such that all the interstices between the fragments of aggregate are filled by the matrix, and to secure this sand is sometimes added, though it is rarely necessary with a well-broken aggregate whose fragments are of various sizes.

For ordinary foundations, especially in lime concrete, it is most usual to employ ballast, or some other pebbly substance, as an aggregate, only the larger fragments being broken so as to pass in all directions through a 2-in. ring this last being a very necessary stipulation, constantly neglected in practice. In no case, however, can such a concrete be really good, as the smooth surface of a pebble is not one to which either lime or cement will readily adhere.

Better aggregates for walls or floors are broken stone, brick or slag, as the fracture is generally clean, having jagged features forming an excellent key for the cement. Round stone, that has been water-worn, is not a good material, especially where the concrete has to bear transverse strains. If gravel must be used, it is a great advantage to use hard, broken brick in conjunction with the gravel, as a certain amount of cohesion is thereby added to the mass which would otherwise be entirely lacking. Burnt ballast concrete is the worst of any; it is impossible to obtain a thoroughly vitrified class of ballast until the cores of the ballast heaps are reached. The outsides are entirely unsuitable for use in damp positions, as the baked clay is readily acted upon by the moisture, and gradually returns once more to its original condition.

For floors, the aggregate is generally crushed much more finely, so as to pass through a f-in. or even a J-in. ring, and for upper floors and roofs scarcely any other aggregate is used than broken brick, pumice-stone, or coke-breeze this last being coke from which all the contained gas has not been quite extracted. It is exceedingly light, and, strange to say, is an excellent fire-resister when made into concrete with Portland cement so much so that the British Fire Prevention Committee have definitely made up their minds that coke-breeze concrete would last in a fire better than any other. This, however, does not apply to the cheaper clinker or pan breeze, which is comparatively valueless.

Text 8. Artificial stone

There are three classes of artificial stones now made Simple Cement Concretes, Cement Concretes which have been subjected to some hardening process, and Chemical Stones. Most of them are composed of a granite aggregate with a matrix of Portland cement, and are either laid in situ or cast in moulds for such purposes as steps and window sills. They have the advantage over ordinary concrete that they are made by the skilled workmen of firms who have a specialist's reputation to lose. One of the simple concretes, " Basaltine stone", differs from the others in that the aggregate is composed of basalt chippings, while trass, a pumiceous conglomerate of volcanic origin, is mixed with the cement. It has the important property of combining with any free lime in the cement, and consequently upon this is considered to be an essential ingredient in concrete used for sea-defence work by the Dutch Government. The hardened concretes include "Victoria stone", "Imperial stone", "Empire stone", "Indurated stone", and others. Of these, "Victoria stone" which has an excellent reputation of long standing, may be considered to be typical. The aggregate used is finely-crushed and well-washed Leicestershire granite, having the following analysis. Three parts of aggregate are thoroughly mixed with one of selected and tested Portland cement in a dry state by machinery, and the water then added in a careful manner, so as to avoid the danger of washing out any of the fine and more soluble portions of the cement; and before any initial set of crude concrete mixture can arise it is put into the moulds, in which it is carefully worked with the trowel, so as to fill up the angles and sides, thus ensuring accurate arrises all round. The moulds are made of wood, which are lined internally with metal, not only to secure accuracy of form, but also to render them durable, and proof against liability to distortion. The moulds, filled thus, are allowed to remain on the benches of the moulding sheds until the concrete has sufficiently set, and a certain amount of the water of plasticity evaporated. The slabs, when sufficiently dry, are relieved from the surroundings of the moulds; which, being made in pieces, can be readily detached by unscrewing the fastenings. The slabs are then taken to a tank in the silicating yard (protected from the weather), placed side by side, and covered by a silicate solution of silicate of soda, where they remain for a period of time which depends on the condition of a slab and its capacity of absorption. About 14 days, under ordinary circumstances, is regarded as sufficient. The slabs, after being taken from the tanks, are stacked in the storeyard, where they remain to season, and are taken away in the order of their age. The machinery required for the conversion of the crude silica into silicate is of a very simple character, consisting of a pair of iron-edged runners to reduce the silica stone, and a series of jacketed boilers, to which steam of the required temperature is supplied, caustic soda obtained from the best sources being added. The resulting "stone" is one of the best paving materials known, being practically non-absorbent, its porosity being only 13%, and wearing evenly and very slowly under the tread. It has a crushing resistance of over 550 tons per square foot. Though mostly used for pavings, it is also cast into copings, steps, balustrades, and many other forms. "Imperial stone" is almost identical with Victoria stone, the aggregate being washed to remove fractural dust, and so permit of closer adhesion of the cement, and the moulds being filled upon trembling frames, while they are themselves made of stone instead of metal-lined wood, to avoid all risk of warping. The slabs are subjected to steam during setting, thereby quickening the setting process and at the same time testing the cement in a very thorough manner. They are allowed one day in which to set, and are then placed in the silicate tanks for three days, afterwards being stacked in the open for six months before being sent out. Large pipes, as well as paving slabs, are made of this "stone", crushed flint being substituted for granite as the aggregate, and steel wire rings being bedded in them, one to every foot of length. Such pipes are well suited for many purposes, for though slightly absorbent they are almost as impervious as stoneware, and in the larger sizes, from 2 ft. 6 ins. to 4 ft. in diameter, are much more accurate in shape; and they can be easily jointed, ogee joints being used. Whether anything is gained by immersion in a silicate solution is a moot point. The makers of the simple concretes deny it, while those who use this bath contend that it is advantageous to do so; and allendeavour to produce a material suited to the needs of their customers. The "Hard York Nonslip Stone" differs from other hardened concretes in having Silex York stone as its aggregate, and in being made under heavy pressure. The stone is not only crushed, but pulverised and reduced to its original sand, the ingredients are run into moulds, and a pressure of over 2,000 tons per square foot is applied, the solid slab being then immediately ready to be carried to the maturing ground, where it is exposed to the weather for at least 8 months. The only chemically formed stone of importance at the present time is Ford's Silicate-of-lime stone. It is made of silica in the form of fine sand and chalk lime in the proportion of from 92 to 95% of silica, to from 5 to 7% of lime,mixed dry and rammed dry into a box mould, which for the larger blocks is cylindrical in shape. The box is made of steel, and has an internal copper lining, both the steel and the copper shells being perforated. A vacuum is created in the boxes, and boiling water introduced under pressure, causing the lime to slake and expand. As the water escapes through the perforations it is replaced by superheated steam under a pressure of 120 Ibs. per square inch, thus ensuring the slaking of every particle of lime, and its combination with some of the silica, forming a cementitious silicate of lime. The whole process of manufacture only occupies eight hours, and the resulting material closely resembles a sandstone, having grains of silica cemented together with silicate of lime, either coarse or fine, or of almost any colour, according to the sand used in its manufacture. Perfectly homogeneous and free from flaws, it can be worked like freestone, for it is purposely not made harder than is necessary to secure perfect cementing of the particles. It has a crushing resistance of from 600 to 700 tons per square foot, and its porosity is 8%. It is consequently not very suitable, nor is it intended, for paving purposes, but for walling and general stonework, including ornamental carving. It is made in blocks, which vary from the size of bricks up to cubes of 6 ft. side. Samples were then submitted to solutions containing 5%, 10%, and 50%, of sulphuric, hydrochloric, and nitric acids for twenty-four hours, with the following results, which were far superior to those obtained with good weathering limestones under the same tests.

Text 9. Sand, gravel, ballast, core, flint

Though the term *sand* may be applied to small grains of any mineral as found in Nature, it is generally confined in its use to those of quartz (almost pure silica), which are found in excessive abundance in the earth's crust. While a white colour is generally an indication of purity of the quartz, it may possibly be due to the presence of carbonate of lime, usually in the form of chalk, which, however, can readily be detected by its effervescence if some be placed in a saucer and acid (hydrochloric or nitric) be poured over it. Any colour, ranging from the lightest tint of yellow to a deep red, will in almost all cases be due to the presence of oxide of iron as an impalpably thin coating to the silica grains, the depth of the colour being an indication of the amount of iron oxide which is present. It has no appreciable effect upon the value of the sand for building purposes, except so far as colour is of importance. Angularity of grit, or sharpness, is generally considered an essential quality of good sand. Fineness of grain is often also essential, especially for the finishing coats of plaster, and to secure it sifting has to be resorted to; but for coarser work it is better to have both coarse and fine particles in the sand, that the crevices between the coarse particles may be filled. Good building sand should be of pure quartz only, with grains of known sizes; for instance, such as will pass through a sieve of 900 holes per square inch, and caught on one of 1,600 holes. It is only by adopting some such specification for a sand that the best results are to be obtained in making mortar. The presence of loam, although it renders sand easier and therefore cheaper to work, if in sufficient quantity to be detected by the touch, or the appearance, or by leaving a stain when rubbed between damp hands, is distinctly harmful, as it will irretrievably destroy even the best cementing material. It should then be removed by washing; but the effect of washing naturally good sand is scarcely appreciable, as is shown by the following tests made, on briquettes composed of 2 of sand passed through a sieve of 900 meshes per square inch to 1 of cement.The best possible way to wash sand for the removal of clay or loam is in a running stream, the force of which is just enough to remove the mud and very fine sand, leaving the fine grit and coarser particles behind. Sand is sometimes sifted and washed by placing it in a sieve held in a tub of water. A quick horizontal motion from side to side causes the smaller grains to pass through the sieve and fall to the bottom; but much dirt is in this way carried down with the sand, so that the process is not to be recommended. It is supposed that the mud remains suspended in the water until it is poured off, and the coarse stuff remaining in the sieve is rejected as being unfit for the work; as a matter of fact, much of the mud is deposited with the fine sand, rendering it quite unfit for mixing with lime or cement. If sand contain salt it may be removed by constant washing in running clean fresh water. The most convenient way to effect this is to construct a washing-tank in the ground, about 6ft. square and iSins. deep, lined with brick in cement. The sand should be filled into this to a depth of 10 ins. or 12 ins., and a stream of water turned on it. A brown frothy scum soon rises to the surface. The sand should be constantly stirred. When the water runs off clear, and without having a saline taste, the sand may be removed for use. It is well to bear in mind that the individual grains of sand contain no salt; that the salt merely coats the grains or lies between them, having been deposited there by the evaporation of salt water; that the salt is soluble in water, and may be entirely removed by careful washing; and sea sand so washed is quite as good for building as any pit or river sand of equal fineness and smoothness of grain. Other methods of "killing" or neutralising the effect of the salt in sea water have been tried at various times, but they have hardly proved successful. Salt is the most harmful substance which sand can contain. It has so great an affinity for moisture that a wall in which it is used is rendered permanently damp. Any sand which is salt to the taste, including all sea sand and a good deal of pit sand, dug from comparatively recent under-sea deposits, should consequently be rejected for all purposes other than for use under water, unless it be first properly washed. Sea sand is also generally rounded by attrition, and consequently wanting in sharpness; and so to a less extent is river sand. Pit sand is of all qualities, it being impossible to lay down any rule. An excellent sand is obtained in the process of washing decomposed granite for the extraction of kaolin, but it is only used locally, the cost of transport being prohibitive. Sand does not absorb water in any appreciable quantity, its bulk is not diminished or increased by cold or heat, and does not contract in drying; therefore the greater the quantity of sand used in mortar in proportion to lime, the less probability there will be of the mortar shrinking and breaking. In erecting new walls on the site of old ones, it is usual to work up the old mortar as sand; but this should not be allowed, as in nearly every case the old mortar, through being made with loamy sand, is valueless for the purpose, and will, if mixed with clean sand, only injure it. The use of old mortar has this to recommend it a much smaller quantity of lime will make it into a working paste than will be required from clean sand. Road-scrapings from hard roads are frequently used with lime instead of sand to make mortar; but as the proportion of grit in them is so small, compared with the mud, horse droppings, and other filth, they do not make good mortar. Scrapings from soft roads are simply mud. Burnt clay, bricks, tiles, and soft stone are frequently broken up and ground to be used instead of sand. These, if free from dust, make a quick and fairly hard-setting mortar; but, unlike sand, they are porous, and consequently will absorb water Mortar made with them is liable to crack and shrink in drying, and where a waterproof wall is required, they should never be used instead of clean, sharp quartzose sand.

Gravel is an extremely coarse sand, as a rule composed to a large extent of rounded pebbles. As found in Nature it generally ranges in the same deposit from fine sand to stones of 3 ins. diameter and more, and in this condition is useful for many purposes; while for others it is "screened", or thrown against an inclined sieve having a wide mesh of strong wire. If a tolerably fine screen be first used, and then what isretained be again screened, and the process repeated three or more times, sands and gravels of several different degrees of coarseness can be separated out. Further than this, gravel, like sand, can be washed if desired to free it from loam or clay; and an excellent *washed gravel* is often obtained in this way from brick earth, being separated out in the wash mill and sold as a bye-product.

Ballast means literally any substance of little value which is shot into a ship's hold to give it stability for a voyage when profitable cargo is not obtainable; but amongst builders the term is restricted to river gravel. This is similar to washed pit gravel, free from loam, and with its particles more or less rounded by attrition. More smooth, and with the further disadvantage of saltness, is Sea Shingle, though the salt is not so pronouncedly present as it is among the finer grains of sea sand. A form of ballast, known as *Burnt Ballast*, is made by burning clay or brick earth in large heaps, the clay being unprepared in any way, but merely dug, mixed with small coal, tipped into a great heap, set on fire and allowed to burn through. In the middle of such a heap a small proportion will be well burnt to a hard clinker, which, when broken to any desired size, makes an excellent substitute for gravel for many purposes such as for concrete and for the foundations of roads; but the underburnt portion, of which there is always much, tends to assimilate moisture and return to its original condition as a soft clay, and so is useless. Burnt ballast is consequently a dangerous material to specify on account of the difficulty of discarding the bad lumps, which are always in excess.

Core, or Hard Core, is a name given to any hard rubbish, such as furnace ashes, dust destructor slag, the dry refuse from dustbins, or the detritus from buildings which have been pulled down. This is frequently used for filling up under concrete floors, it being difficult to find anything better provided it contain no vegetable or animal matter, that there be enough small stuff in it to fill up crevices and make it bind, and that it be well rammed. The size of the fragments of which it may consist is of little importance, nor their substance, which may vary from old tin trays to broken crockery and jam pots. *Flints*, which are composed of almost pure silica, and are found in all chalk deposits, occur in curious globular and rounded shapes, and break with smooth surfaces and sharp edges. They cannot be cut with the chisel, but will break under the hammer, and a skilled workman can bring them to rectangular shape and a good face for wall facing. They resist wear excellently and make thoroughly good road metal and filling material under floors. The strange shape and the minute structure of flints show them to be mineral aggregations which were formed round a nucleus of decaying organic matter. Certain organisms, such as sponges and diatoms, provide themselves with silicious skeletons or coverings, the material for which they obtain from the water, and these organisms when decayed furnish silica for the flints. Flints, therefore, grew in the chalk after it was deposited as mud, and they did so by the gradual accretion of silica in an amorphous condition which had previously been held in solution by the sea-water in which the chalk mud was deposited.

Text 10. Bricks: the principal varieties

Bricks are small artificially made building blocks, usually, though not invariably, made of clay in moulds, and raised to a high temperature, with the effect that the soft clay is converted into a hard material, which wears and weathers well, the silica and alumina of which, together with water, oxide of iron and carbonate of lime, the clay is composed combining in very complex manner. As different clays vary greatly from one another, no two being alike, it is not possible to give a general analysis; nor will analysis always denote how the clay will behave during brickmaking. This can only be determined by experiment, which is often extremely costly. Roughly speaking, however, the alumina gives the plasticity necessary to enable the clay to be moulded; the silica prevents undue hardness and shrinkage; the oxide of iron helps to bind the brick and is its principal colouring ingredient; and the carbonate of lime is a binding material. The plasticity also depends upon the water. That with which the clay is mechanically combined can be expelled at a temperature slightly above 212 Fahr. without detriment to its plasticity; but the whole of the water in the clay cannot be driven off without raising the temperature to dull redness, and the clay under these circumstances loses its plastic properties, nor can it be made to re-combine with water so as to recover its plasticity thus, for example, powdered brick will absorb a great deal of water, but it does not by such absorption regain the plasticity possessed by the clay of which the brick was made. Of late it has become customary to add about an ounce of carbonate of barium to every cwt. of clay intended to be made into bricks to prevent discoloration, and the appearance of surface scum. One of the chief causes of scumming is the presence of soluble salts in the clay itself, and also in the water used for tempering purposes. These soluble salts, by the combined action of the water and heat are driven to the surface of the brick, and cause the white discoloration called scum. The majority of these salts are Sulphuric Acid Salts, the principal one being sulphate of lime or gypsum.

Now, if sulphate of lime and carbonate of barium are brought together in the presence of water and heat, a chemical change takes place, and insoluble sulphate of barium and insoluble carbonate of lime are formed, thus: Sulphate of Lime, Carbonate of Barium, or and in this way the soluble gypsum and scum causing impurity becomes changed and rendered harmless. Sulphate of Magnesia would be decomposed in a similar manner. A thoroughly good brick should be regular in shape, texture and colour, equally and perfectly burnt right through, free from all cracks and flaws, even though they be hair-cracks, and sharp in the arrises; and should give out a clear ringing sound when struck either with a stone, other bricks, or metal. For many purposes, however, it is unnecessary to insist upon all these qualities. Any hard and well-burnt brick will suffice for foundations and for internal work which is to be subsequently covered; and for such purposes the cheaper and rougher bricks are frequently the more useful, as affording a better key for plastering than those with a smooth surface, and often being better weight-carriers than soft, well-finished, hand-made facing bricks. Sandy and absorbent bricks should not be used in foundations, nor in external walls where likely to be exposed to driving rain. Such bricks are generally soft and do not weather well, being frequently underburnt; and by retaining moisture they encourage the growth of lichen and climbing plants, which all gather and retain damp. Soft, underburnt bricks are valueless. No brickmaker with a reputation to lose will sell them, preferring to pass them through the kiln a second time, or to crush them for sand. On the other hand a markedly non-absorbent brick, heavily pressed and highly burnt, may have too smooth a face to adhere readily to mortar, especially in summer time, in spite of good wetting. Over-burnt bricks will melt and run together, forming burrs which are useless except to be broken up for road metal or concrete. Faulty bricks are more often met with amongst those which are hand made, hack dried and clamp burnt than amongst those which are modern machine made, chamber dried, and kiln burnt. To tabulate the many different kinds of bricks now made in England would be an almost hopeless task. On the other hand, those which are used in London are commonly, and in a very general manner, classed as either Stocks, Flettons, Sand-faced bricks, Rubbers, Pressed bricks, Blue bricks, Glazed bricks, or Clinkers.

The term “stock brick” is in use in many parts of the country to denote the particular kind of brick most commonly made for general use in that particular district; but it is being gradually less and less employed in this way as machine making is supplanting hand moulding, and is becoming recognised as the generic name of a class of brick made largely in the London district and nowhere else, from a thin superficial layer of natural clay. The London stock brick is coarse, hard and strong, and grey or yellow (or red) in colour. The fuel is mixed with the clay in manufacture, causing it to be exceedingly irregular in structure and colour, and frequently cracked; but if well burnt it is an excellent brick for general internal walling, backing and foundations, being vitrified right through, and it is frequently blue in the middle, as displayed upon fracture. The strength of brickwork is much less than that of bricks, and varies so largely with the quality of the mortar, and particularly with the workmanship, that no reliable data can be obtained. The lower qualities of stocks are known as “place bricks”, “grizzles” and “chuffs”; but these are local terms only, and need no definition.

Fletton bricks (flitters) are machine-made and kiln-burnt bricks from an unprepared clay found in a deep bed in the neighbourhood of Peterborough, the quality and colour varying considerably according to the exact locality and the part of the bed from which the clay is obtained. They are cheaply produced in large quantities for ordinary internal work and foundations, being about as hard and strong as stocks. Though some are of a good and even red colour, most of them are khaki-coloured a dirty grey and so unsuited for facing. They have a peculiar and distinct grain, something like that of a coarse oolitic limestone, and a smooth surface to the grains, which are well cemented together, on which account it is sometimes thought that plaster would not adhere to them well, though in practice this objection has hardly been found to hold good.

Sand-faced bricks are very largely used in London for facings. They are generally of a red and even colour, often beautiful both in tone and texture; but they are necessarily soft and absorptive, being made from a light and sandy clay, generally unpressed, or only lightly pressed, in manufacture. As a result, the lower qualities do not weather well, but pit and crumble in the course of a few years, especially when used in the lower courses of a building and subjected either to damp or wear. It is consequently necessary to carefully apply the test of tapping, to ascertain the “ring”, when it is desired to use such bricks, and to reject all which sound dull; while an even better guarantee is to use only bricks from a well-known field having a high reputation.

Rubbers are soft, sandy bricks, invariably hand made, of such a nature as to be uniform in colour throughout, and to be nearly as weather resisting if the outer skin were removed as if it were retained. Thus, as their name implies, they are capable of being rubbed down to any desired shape and to a smooth surface, and even of being carved. Both red and white rubbers are made, but the red ones are the more satisfactory, having a deservedly high reputation, and almost a monopoly.

Pressed bricks are, if red, made as a rule from stiff, plastic clays, and if white from gault clays, the red colour of the one being caused by the presence of oxide of iron and the white colour of the other by the presence of lime. Buff-coloured facing bricks are also made from the Devonshire stoneware clays, such as those from the Marland pits near Torrington, illustrated in the accompanying photographic plate. In either case the bricks are almost invariably machine burnt, artificially dried and kiln burnt at a sufficiently high temperature to secure vitrification right through, with resulting close and uniform texture and great strength. They are also much heavier than hand-made and unpressed bricks, and so are frequently made with two frogs, or else are perforated, while they are capable of being stamped with a great variety of patterns in the press. Pressed bricks vary but little in size or shape, and have sharp arrises and a smooth surface. They are consequently suitable for all high-class work, making excellent facing, and, where their cost is not prohibitive, backing also, those which are most free from discoloration and from accidental chipping being selected for facings.

Blue bricks are made from a clay containing from 7 to 10%, of oxide of iron. They are burnt at an extremely high temperature until they almost melt, and not infrequently stick together in the kiln. They are extremely hard, with a glassy surface, and of a slightly honeycombed vitreous structure. Other equally strong bricks are made, but as these carry on their face, in their deep blue-black colour and glass-like appearance, a guarantee of thorough burning, they are almost invariably used where great strength is necessary, or where they are to be exposed to heavy wear or to an acid atmosphere.

Glazed bricks are of two kinds, “salt-glazed” and “dipped”. To produce the former of these salt is thrown into the kiln during burning, a thin glass coating being then formed upon all exposed surfaces of the bricks, care being taken to previously protect all beds and other surfaces which it is not desired to glaze. The bricks retain their natural colour and surface, the glaze penetrating every crevice, and being extremely thin, though absolutely one with the general structure, so that peeling is impossible. The glaze of a “dipped” brick may, however, be of quite a different colour from its general body, the brick being, as its name implies, dipped into a “slip” of specially prepared clay, either before burning or when half burnt, of such a character that a smooth face is produced, similar to that of china. The preparation of the slip is a very special matter, and great care is necessary in all the processes of drying, mixing the slip, dipping and burning, else discoloration will result, or the glaze will crack or peel,owing to its not contracting uniformly with the rest of the brick when in the furnace.

Clinkers are small, thoroughly vitrified bricks, used mostly, if not entirely, for pavings. They are of light yellow colour, machine made and pressed, and consequently heavy, dense, and almost impervious to moisture. *Terro-metallic clinkers* differ from these in little else than colour, being dark brown or nearly black.

Fire-brick is the name given to brick burnt from any highly refractory clay, usually one containing a large proportion of silica and little alkali, and capable of withstanding great heat. Such bricks are always highly burnt and compact in texture, and generally have a smooth-feeling surface. They vary much in quality, and are made of many shapes and sizes, according to the purpose for which they are required, some of quite moderate heat-resisting power being shaped to form fire-backs for grates; while others of an exceedingly refractory nature are made like ordinary bricks, or specially moulded to radius, to serve as furnace and chimney linings. A large amount of suitable clay is found near Stourbridge, where much of the fire-brick of this country is made, but in many other places the ordinary brick, terra-cotta and stoneware earths so nearly approximate to fire-clay that they can be used as satisfactory substitutes under moderate conditions. True fire-clay also is found in many parts of the country, generally amongst the coal measures, and in many cases, either with or without admixture with other substances, is moulded and sold as ordinary building brick or stoneware. It is exceedingly difficult, however, to draw any hard-and- fast line, as the following table of analyses and peculiarities of three well-known clays will clearly show, for they differ widely from one another in almost every particular except the possession of the valuable quality of resistance to fire. Refractory fire-clays are of two classes: 1) The silicate of alumina class, in which the alumina is about half the silica, and the latter is mostly in combined form. 2) The silicious class, in which silica predominates up to about 90%, mostly in the free state, and the alumina is low. The former class has the most plasticity for working, and is harder when burnt, but both are refractory in the furnace, provided they contain low percentages of iron oxide, lime, and magnesia, which, especially the two former, are the cause of fusibility. For fire-brick: a) Lime and magnesia together should not exceed 1%, b) Iron oxide should not exceed 2 to 2j %, c) Both should be preferably lower. d) Alkalies may reach 2%. It is of very little use to build fire-bricks in mortar. They should be laid in fireclay capable of resisting as great a temperature as the bricks themselves; and under many circumstances, especially in furnace building, it is customary to build the structure of lumps of unburnt fireclay, welding it into one homogeneous mass by gradually heating up the furnace itself.

Earthenware and stoneware names which are often indifferently applied to clay goods of miscellaneous character, generally made from mixed earths, or of clays mixed with sand and broken pottery and stoneware. If any distinction can be drawn between them, it is that earthenware is made from milder clays, burnt at a comparatively low temperature, more or less porous, and approximating to terra-cotta in character; while stoneware is made from more refractory clays, burnt at a high temperature, well vitrified, close grained, hard and impervious to moisture, and approximating to fire-brick. Between these two extremes, however, there is every grade and variation. As a general rule, the harder stoneware is of a light straw colour, while the softer earthenware is dark brown, but upon this point, as the others, it is impossible to be didactic. Most ware goods used in building operations, such as drain pipes, sinks, and baths, are used in connection with water, and are glazed. The glaze is itself impervious to water, but it is exceedingly thin, especially the salt glaze usually applied to pipes, so that the main substance should be as non -porous as possible; and as a salt glaze can be applied to goods when burnt at a high temperature, there is no reason why the necessary degree of vitrification should not be present when it is used. The test is by observation of a fracture, to see that it is compact throughout, and by tapping, when, if underburnt or cracked, it will emit a dull sound, while if well burnt and sound, it will ring true. Correctness of shape is, naturally, tested by observation, and is generally of importance, as warped pipes will not properly fit one another, and warping is by no means uncommon during manufacture. Dipped glazes are thicker than salt glazes, but will rarely stand so high a temperature, so that a perfectly impervious backing is not so generally to be expected, nor is it so necessary with dip-glazed ware.

Terra-cotta is the name given to any burnt clay or mixture of clays which vitrifies on the face at a moderate temperature with a smooth, hardened surface, and is used in blocks as a substitute for stone, particularly in ornamental work. So long as the outer skin remains intact it is practically indestructible by acids or weathering, and so is an exceedingly useful material for external walling in towns and by the sea-side, especially as the hard surface is sufficiently wear-resisting for it to be used successfully at a low level upon a street frontage, while it is strong enough to carry safely any ordinary load. Its decorative possibilities are also considerable, as it can be obtained of all tints, from a light buff to a deep red, according to the proportion of oxide of iron contained in it, this reaching as much as 10%, in the richer tints, and can be made of almost any shape within a limit as to size of about 3 cubic feet. Solid terra-cotta weighs about 122 Ibs. per cubic foot, but it is generally made in hollow blocks, about 2 ins. thick, with connecting webs across the hollow spaces. In this condition it is too light for walling, and the hollows are generally filled with lime concrete, which can be trusted not to expand and burst the blocks. Projecting mouldings and cornices, however, ought not to be filled. Most fire-clays can be made into terra-cotta, with little preparation, and then have excellent texture, colour and surface; but the interior is rough and porous when the outer skin is removed, whereas it is homogeneous and smooth in the true terra-cotta. In no case, however, ought the interior to be exposed (by rubbing or chipping to bring down accidental irregularities), as it is by no means so wear or weather resisting as the surface.

Brickwork. So far as possible the standard size of a brick, with a sufficient allowance for joints, should be used as the unit for all dimensions. Thicknesses of walls must, consequently, be in multiples of 4 ins. (half a brick). Lengths may, without cutting unduly, be in multiples of 2j ins. (the width of a closer), though any lengths can be obtained by cutting and rubbing. Heights should all be in multiples of 3 ins. (the thickness of a brick), to avoid the necessity of packing with pieces of tile or broken chips of brick. Receding courses, as in footings, are preferably built in headers in 2 J-in. off-sets; and so are corbel courses if they have any weight to sustain. If backing and facing are of different kinds of bricks, they should be so selected in thickness as to bond properly, due allowance being made for the finer joint used in external work. Unless there be very strong reason to the contrary, all cants, squint quoins, and bird's-mouths should be worked to the angle of 45 degrees. For all other angles the bricks have either to be rubbed or specially made. Bricks of unusual sizes and of special contour are always to be obtained by having them specially made, but as a general rule their cost is prohibitive. Rigid adherence to such mouldings and enrichments as are easily procurable is the only safe rule where means are limited. Keep in mind the standard sizes of the bricks you will use when planning. Thoroughly sound bond can only be secured if the distances between openings, and between cross walls, and the widths of openings, are arranged to brick dimensions. If these be not adhered to, bricks must be rubbed to fit or are more often roughly broken and the bond destroyed. This is particularly necessary when using hard, pressed facing or glazed bricks. Uniformity of colour, where required, is only to be obtained by using bricks from the same maker. Thus it would be unwise to make up a group of mouldings from the catalogue sections of several different firms. All bedded timbers should be to brick dimensions so far as they are enclosed in brickwork. Rubbed and carved work should be so devised that all bricks can be worked down to fit from the bricks to be used.

Terra-cotta. Get out drawings full size for manufacturers or if to a smaller scale, dimension everything exactly. Make no allowance for shrinkage the manufacturer will do this. Work to the dimensions of the particular bricks you intend to use, so as to secure proper bond, allowing for the thickness of mortar joints. Avoid undercut mouldings and enrichments. Though possible to model, they are difficult and often impossible to mould and cast, and so have to be applied by hand and the risk of nonadherence taken; or else the manufacturer will alter your detail to make it practicable. Keep all sweeps true, so that they can be struck from a single centre with a running mould. Use repeats as much as possible, remembering that any variation in the size of a block, whether it be plain or enriched, will involve extra expense in the production of special shrinkage-scale drawings and a special model. On the other hand, mouldings and enrichments can be varied in blocks of the same size by the introduction of movable sections in the model. It is an economy to make such things as gable parapets of the same section back and front, as then the same model can be used for both right and left stop ends, mitres and kneeler blocks. A certain amount of shrinkage and warping being unavoidable, it is unwise to design too much in straight lines and regular curves, unless the mouldings be enriched sufficiently to render any slight twist imperceptible. A large amount of such enrichment is possible without materially increasing the cost, as it would do if it had to be carved in stone.

Text 11. Brick, terra-cotta and tile making

Brickmaking by primitive methods is an exceedingly ancient industry, and although machinery is now used in most brickfields, the old processes of hand manufacture are still largely employed, especially in temporary brickfields of small extent, and wherever a common brick is made from a surface clay; and also in some instances where high-class bricks are made which require special personal attention in order to secure some particular characteristic. This is the case with the well-known rubbers, made at large fields, at Swinley, near Ascot, which are required to be soft enough to be rubbed or carved, well burnt right through that surfaces exposed by carving may weather as well as the outer skin, and of uniform colour throughout their substance. At these works the clay is dug, mixed in a large wash- mill, and run into a back to dry, whence it is again dug and passed into an elementary pug-mill somewhat like a large barrel, standing upright, in which knife blades revolve on a central vertical shaft. This delivers the clay to the moulder much of the consistency of dough, nearly dry and of fine sandy grain. The moulder has in front of him, on a rough table, a board with a raised centre (to form the frog or hollow in one side of the brick) about 10 ins. by 5 ins. in size, over which he places a wooden box or mould with neither top nor bottom, so that the bottom is formed by the board. This box he sprinkles with sand from a heap beside him. From another heap he then takes a lump of clay, kneads and rolls it for a moment, and in a single motion lifts it and drops it into the mould, so as to fill it perfectly without pressure. Then taking a bow, having piano wire for string, he passes it over the top to cut away any superfluous clay, and this he removes by hand, leaving the top smooth. A smooth board (a pallet) is placed on this, and the mould turned over on it and lifted off, leaving the brick on top of the pallet. Several of these “green” bricks are placed on a barrow and wheeled to a drying shed, where they are stacked with many more and left under cover but exposed to the air to be subsequently removed to the open and piled in hacks or long rows with sloping boards over them to keep off the rain and the sunshine. When about half dry, they are restacked, or scintled, into similar rows with more air space between, about fourteen courses high instead of six or eight, as in the drying sheds and hacks.

Drying by this means occupies a considerable time, and a good many bricks are spoilt during the process by cracking, warping, or breaking, and have to be sent back to the pug-mill and remade. The great majority, however, are passed on to be burnt in Scotch kilns. These are large chambers open to the sky with a series of fine holes down each side, opposite to one another. The raw bricks are piled up in these kilns in such a way that flues connect the fire holes, and so that the fire can pass freely between and around the bricks from bottom to top, the top being generally formed of old burnt bricks. When the kiln has been filled, or "crowded" as it is termed, it holds, according to its size, from 30,000 to 70,000 bricks. The ends, or doorways, are bricked up and plastered over with clay, and fires lit in the fire holes, the heat being gradually increased till all contained moisture is driven out, when the fires are burnt briskly until the top falls in. This is a sign that burning has sufficiently advanced, and that the fires may be allowed to go out and the kiln to cool. As a rule the bricks will be found to vary in shade, those nearest the eye holes being the darkest in tint, and it is customary to sort them accordingly; but if the burning has been carefully done there should be but few spoilt through over or under burning. The harder burnt and darker bricks, however, will be found to have shrunk more than those of a lighter colour, the difference in size in the case of unpressed hand-made bricks being often considerable. When bricks of a more common character, such as the London stock bricks, are made by hand, it is more usual to burn them in clamps than in kilns. These clamps are, however, little more than heaps of bricks, themselves having fuel mixed with the clay, built up with a casing of old burnt bricks to somewhat resemble a Scotch kiln, fuel in the form of dust coal being sprinkled between the layers of bricks, and fire holes and flues being roughly formed. The process is slow, extravagant and wasteful, much fuel being necessary, and the resulting bricks being exceedingly rough and unequal in quality, some being soft and valueless, and others in the same clamp so highly burnt as to have run together into vitrified masses or burrs, useless for any other purpose than to be broken up for concrete or sold for ship's ballast. Wherever large numbers of bricks have to be made, of good quality, it is necessary to employ machinery. This varies considerably, that which is suitable for one kind of clay being unsuitable for another. At Hill End the clay occurs near the surface, almost like a gravel, containing a great amount of flint, which is sifted out and sold as road metal, while the clay is wheeled and tipped into a circular wash-mill containing an ample supply of water, in which it is churned up by revolving beaters. A 11 stones in. or more in diameter which have passed through the sieves settle in this mill as a sediment, and are cleared out once a week, the washed clay, in a liquid state, being driven through an overflow grating, which only allows particles less than J in. wide to pass, into a sump-hole 6 ft. deep. This thin slurry is pumped from the sump at a pressure of 20 Ibs. per square inch up a long pipe to troughs, whence it gravitates to large square “backs”, or hollows cut in the earth, each of which can be filled in turn. Here the clay is allowed to settle, the surplus surface water being returned to the wash-mill, and the now partially dry clay in the back is covered with a thin layer of “commons”, or unwashed clay and sand, and left to evaporate and harden to the consistency of butter, which it considerably resembles. In this state it is dug out, loaded into trollies, and hauled on to an upper floor, where it is mixed with a certain proportion of crushed brick to bring it to a proper consistency, and passed downwards through rollers to a pug-mill containing revolving knives and thence to the moulding machine in a lower room. The moulds, each for six bricks, are made of wood. They are sanded automatically and passed into the machine where the clay is pressed into them, and as they come out are roughly “struck” by the machine, and then are hand struck to bring them to a level surfaceand are lightly sanded over. The moulds are now turned on to pallets, or boards, which lie on a revolving turntable, and the wood moulds are lifted and returned to be resanded and passed through the machine again while the pallets are transferred to racks or carriages running on railsand passed into a large drying chamber. There the bricks are subjected to a constant stream of hot air forced in by fans, at carefully regulated temperatures a low temperature when the bricks first enter the chamber, gradually altering as the carriages pass on their rails from end to end of the chamber, till a considerable heat is attained near the exit doors, each carriage, as it enters, pushing forward those in front of it on the same rails. Thus as each carriage full of raw bricks is introduced at one end, a carriage full of dried bricks emerges at the other, he time between entry and exit being 22 hours. Very few faulty bricks are found on emergence from the dryer, and these are immediately taken out and returned to the pug-mill, while the sound ones only are passed on to the kiln, which is a modification of the “Perfected” type. “Perfected” kiln, which is of the improved Hoffman type, and serves the double purpose of drying chamber and kiln. If the kiln is in full working the conditions will be somewhat as follows: Chamber 14 has just been stacked with green bricks; chambers 13, 12, and 10 contain bricks in increasing degrees of dry ness, while in chamber 9 the firing has just commenced; chambers 8, 7, and 6 are in full firing; chambers 5, 4, 3, and 2 are in various degrees of cooling, the bricks in chamber 2 being ready for unloading; while chamber 1 is empty. In crowding a chamber, spaces are left so that when the chamber is fired through the holes in the top the fuel falls onto the floor of the kiln; spaces are also left between the bricks so that the heat may play all round them, while under the arches between the chambers the bricks are packed closely together so as to form a dividing wall between the chambers. To dry chamber 14 the loading door and damper door are blocked up, and the up draught steam flue, down draught steam flue and hot air flue are opened, and the hot air passes from the cooling chambers through the green bricks, carrying away the water they contain in the form of steam. The up and down draught steam flues are built at opposite ends of the chamber so that the hot air may circulate more thoroughly. It has been stated above that the firing has commenced in chamber 9, by which is meant that the fire has been gradually drawn along the tunnel until the fuel under the first row of fire holes has ignited. The bricks round these fires become heated, and the heat gradually passes along to the next row of fires, and so on. Thus the fire creeps round the kiln, its rate of progress being regulated by means of the dampers. With this kiln it is possible to burn seven chambers per week, or in the event of a breakdown of machinery, any less number, even down to one only. The firing being distributed throughout the kiln enables a very uniform brick to be produced, while only 2 cwts. of coal are used to produce 1,000 bricks. It should be noted that the waste gas from the fuel should not be allowed to come in contact with the wet bricks, as it produces an unsightly stain. At Ruabon the clay occurs as a hard rock in a great open quarry, whence it has to be obtained by blasting, and immediately ground to a coarse grit and stacked in the open for two months in order to weather. At the end of that time it is passed into a pan revolving under rollers for further grinding, and fed from thence to a hopper which passes it between rollers set J in. apart, thence along a mixing chamber containing revolving knife blades which pass the clay forward to other rollers which actually touch, and which, though of the same diameter, travel at different speeds, grinding the clay extremely fine. At each operation a little water is added, and the action is very similar to that of a mincing machine, the clay eventually emerging through a shaped die as a plastic band a rectangular die about 9 ins. by 4 ins. being used for ordinary bricks, bull-noses and other sections being formed by varying the shape of the die. A frame set with stretched piano wires 3 ins. apart is now drawn transversely across the ribbon or band of clay, and the separate bricks thus formed are slid on to a table on wheels and carried to the drying chambers, if only common bricks without a frog are needed, and thence to kiln. Hard, compacted bricks are made by passing them through a press before drying. The press is somewhat like the familiar letter-copying press, with heavily-weighted horizontal arms which, on being swung round, bring an upper die on to the brick previously slid into a sinking beneath it. This sinking has a falling bottom resting on springs with the frog or maker's name raised on it. As the upper die, either plain or with a second frog, descends, it pushes the clay and the bottom on which it rests down to a firm seating at such a depth that the entire brick is enclosed within smooth steel sides. It is thus pressed to an exact size, and as the dies accurately fit the casing it is given sharp arises. When the upper die rises, the spring raises the lower die and the brick which rests on it up to the level, whence it is removed by hand.

Drying is at Ruabon accomplished by spare heat from kilns and from steam pipes, and the burning is in vaulted or domed kilns, similar to one another in gene al idea. The vaulted kilns are rectangular on plan and are filled from doors at the ends which are bricked up when the kiln is full. There are from 8 to 10 fire holes along each side, and the heat rises between the inner casing and outer wall, and passes downwards through the bricks to a perforated floor and thence to an air duct leading to a chimney. Each kiln is of one chamber only, which has to be independently filled, burnt and unloaded, occupying a good deal of time, but permitting of careful work. At Conyer the clay occurs naturally in a condition in which it is fit for conversion into an ordinary brick in this case the well-known yellow London "stock" without washing, grinding, or other preparation. It is dug and tipped at once, mixed with a small proportion of coal dust to act as fuel, into a pug-mill, whence it passes directly to the moulding machine, and thence as moulded bricks to and through a long drying chamber, the operations of moulding and drying. So thorough is the drying, that even the hygroscopic moisture is driven out, and all irregularities and superficial discolouring due to the presence of water in the kiln is avoided. The kiln used is a long tunnel through which a single line of rails passes. The bricks, fresh and warm from the drying chamber, are reloaded on to larger carriages and passed while still warm into the kiln, which they pass through from end to end just as they had passed through the drying chamber, each as it is introduced pushing along its predecessors. Burning takes place about the middle of the kiln, no fresh fuel being introduced, though a few "live holes" are provided in its arched top for use in case of necessity, and when the kiln is first lit. A current of air is introduced at that end of the kiln from which the bricks emerge, and passes out to a chimney shaft at the end at which they enter, thus cooling the burnt bricks and gradually heating up the unburnt until they, too, reach the temperature at which the fuel they contain ignites. The bricks when they come out of the kiln, direct into the open air, are still hot, but in a few minutes they are cool enough to handle, and can be run down, on the same carnages on which they were stacked for burning, to barges for shipment. This process is the most rapid and most economical yet introduced. The bricks are ready for the market in four or five days from the time when the clay is dug; more than 10,000 bricks are burnt with 1 cwt. of coal dust; the kiln is one of the cheapest both to build and to maintain of any yet invented; and the proportion of cracked and inferior bricks is very small not more than 5 per cent. In terra-cotta making the clay, in the form of a hard rock, is obtained from the same quarry as is the brick earth, only from a different portion of it, and is blasted, ground and tempered much in the same way. It is mixed with one- third of its bulk of brick dust and a certain proportion of sulphate of baryta and well kneaded up and filled by hand into moulds, removed when sufficiently dry to stand alone, further dried in warm air, and then burnt in the centre of arched or domed kilns while bricks are burnt round the sides, securing uniformity without excess of temperature to the terra-cotta. Warping, twisting and cracking often take place during drying and sometimes during burning, and though small defects of this sort can be "doctored" if they show themselves early enough, blocks which display them in the finished condition should not be introduced into good work. The preparation of the moulds is a troublesome and expensive operation. Full-size drawings have to be made of every block to a proper "shrinkage scale"; and as the allowance to be made for shrinkage varies from of the lineal dimensions in fireclay to terra-cotta clays, these drawings must be made by the manufacturer according to the known peculiarities of his material. Models are then made from these drawings, and plaster of Paris moulds taken from the models, the moulds being made in sections in wooden boxes, the surface of the model, and also any adjacent sides of the moulds, being smeared with soft soap to prevent adherence. The moulds rarely survive more than one filling, but the models can be used over and over again, their life being determined by that of the material of which they are made. It thus follows that the more repeats are required from the same model, the cheaper is terra-cotta in use, especially in elaborate work, in comparison with stone; while, on the other hand, a single object in terra-cotta is expensive. Such objects as ridge-crestings, however, are made quite differently, being expressed through a die to the required section on the sausage-machine principle, and wire-cut to the required lengths. Ornaments are fret-cut by a bow having a piano-wire string by hand to any desired pattern, and any necessary laps are put on by hand.

Tiles also are now generally expressed in thin bands, wire cut, and then pressed to any desired shape, whether they be floor or roofing tiles. The longitudinal bend of an ordinary plain roofing tile is, however, formed by hand over a leather saddle, while any nail holes are punched, also by hand. Before being pressed, it is generally necessary that tiles should be stacked for a short period under cover, close together, in order that they may recover "structure" lost in the expressing. Embossed floor and wall tiles are made by using a sunk die in the press; while a raised pattern leaves hollows in the tile which can be afterwards filled with a differently coloured slip, thus forming encaustic tiles. Such tiles are generally backed with a coarse clay to prevent warping. Imitation encaustic tiles are made by printing a pattern upon the surface in coloured clay. Tiles are frequently half-burnt to "biscuit", and then dipped into plain or coloured glazes, by which means rich and decorative effects are possible. Almost all colours can be obtained, and by printing or hand- painting these can be partially applied. Frequently when this is done several burnings are necessary for the several colours used, and extreme care in the manufacture is necessary owing to the unequal expansion of different glazes at kiln temperature and their consequent liability to crack and peel. Tiles of this nature are known as Majolica tiles. Delicate clay vary of this description is almost always enclosed within large clay jars, known as seggars, during burning, to protect it from any smoke which might injure the glaze; and the burning is accomplished in domed kilns, in which the temperature is under almost perfect control.

Text 12. Bricks, tiles, pipes: their most common sizes and shapes

Bricks are made of many different shapes and sizes:

1.The length of the brick should be double the width, plus the thickness of one vertical joint.

2. Brickwork should measure four courses of bricks and four joints to a foot. Joints should be J in. thick and an extra making for the bed joints, to cover irregularities in the bricks.

This is to apply to all classes of walling bricks, both machine and hand made.

This determines the standard size of a finished brick to be 9 x 4 x 2-JJ- ins., with a slight allowable variation. Whether this can be rigidly enforced in the case of the softer hand-made bricks is open to question, as the same clay from the same mould and burnt in the same kiln will, if unpressed, give bricks which vary much more than this in size, according to the position in the kiln which they may have occupied during burning. Most bricks are made with a “frog” or hollow on the upper surface, as a key for the mortar joint, but some heavy bricks are made with two such hollows, on upper and lower surfaces, or are even perforated, to reduce their weight, and some inferior bricks have no hollows at all. The weight of such bricks varies from 2 tons 13 cwts. per 1,000 for soft hand-made bricks, up to 3 tons 5 cwts. per 1,000 for those which are machine made and pressed. The possible variations are, however, endless, as is testified by the many catalogues of moulded and enriched bricks issued from the larger brickfields.

Roofing tiles, whether used upon roofs or as tile-hanging, i.e., flat thin slabs of burnt clay, slightly bent longitudinally, and either provided with nibs so as to hang on the laths, or else holed for pegs or nails, or often with both. The tails, or lower ends, can be cut into a variety of patterns, though they are more often left square. The usual shapes and Plain, Fish Tail, Club End, ins. x 6jins. logins, x 6Jins. logins, x 63 ins. The angle tiles are intended for vertical tile-hanging only, while hips and valleys are only made to certain common angles, and, in fact, a really satisfactory valley tile has never yet been designed. Corrugated Tile, tiles are used at verges. The roofs on which plain tiles are laid should have a pitch of at least 45 degrees. For the roofs of sheds and temporary buildings, pantiles and corrugated tiles are much used. They have a handsome appearance but are difficult to make wind-tight, and are easily stripped off by a high wind. They can be laid to as low a pitch as 25 degrees. With ordinary flat-surface tiles there is so great a liability for wind to strip the roof, or at least to drive rain up between the tiles, that many different forms have been patented with a view of overcoming these defects, most of which make handsome as well as water-tight roofs, though they present difficulties at the hips and valleys Section of 3 Tiles which cannot easily be overcome except by closecutting and the use of soakers; though in some cases special ridges and hips are made. Of these special tiles, perhaps the most simple is Watson's Flute-faced tile about which it is claimed that any rain beaten up along the exposed fluted surface is stopped where the flutes cease.

The Somerset Patent Interlocking tile is made so as to lock and fit accurately, and it is claimed for it that it may not only be used safely in the most exposed situations, but that it is much lighter than plain tiling, consequently needing less timber to carry it, and that it is cheaper even than slates. The tiles are made I5jins. x 8 ins., to give a 3-in. lap with tiling laths 12 ins. apart top to top. Under these conditions 160 tiles are required per square of 100 ft, and 500 tiles weigh one ton. Glass tiles are made to match. Major's Interlocking tiles are made to fix without nails in four patterns, Plain, Double Roman, Angular, and Welbeck. The section is of the Plain pattern, showing flat bearing at lower end of the tiles, which prevents wholesale breakage by workmen passing over the roof, and the ribs and fillets that stop wind and rain from passing underneath. Besides the ordinary forms of ridge, which cannot be adjusted to variations of pitch, there is one known as Pascall's Patent Expanding ridge, which is adjustable and can be used either for hips or ridges. The tops and wings are each I ft. long, and a length of 250 ft. weighs one ton. The most general forms of drain pipes, connections, traps, gulleys, etc., but there are also many patent forms upon the market, each of which has its own special advantages. Drain pipes are generally salt glazed.

Text 13. Artificial bricks and miscellaneous walling substances

Building blocks of the same size as ordinary bricks are made of several other substances besides burnt clay, mostly for rough work and hard wear.

Concrete bricks are made by many firms, and vary from lime and pebble to Portland cement and granite chippings in composition. They can be made very cheaply by unskilled labour, and would probably come into general use, especially in districts where the raw material is readily obtainable, if from any cause the price of clay bricks were to materially increase. They are largely used in some parts of Europe, for backing to stonework, foundations, cross walls, and for external walls which it is afterwards intended to treat with stucco, for which they afford an excellent key if a pebbly aggregate be used.

Artificial stone bricks are made by some of the firms that manufacture artificial stone, and partake of the same characteristics.

Slag bricks are made directly from the slag from blast furnaces. The slag, as it is run from the furnace, is poured into iron "jackets", which have no bottoms, but rest on the iron table of bogeys, all joints and the outlet being pugged with clay. The bogeys are wheeled, when full, with the aid of small locomotives, in front of a large horizontally revolving wheel, attached to the circumference of which are a number of cast-iron moulds, into which the slag is poured from the jacket in rotation. As the wheel revolves, the bricks cool sufficiently for the moulds to be opened so that they drop out, the moulds being then ready to be refilled as they again pass in front of the jackets; while the bricks are thrown without fuel into an annealing oven, whose doorway is bricked up when it is full, and there left to cool gradually. The bricks produced are hard and heavy, glassy in structure, cream-coloured externally, and blue on fracture. They are used for paving purposes, especially for street crossings, while curbs and channels are also cast. Unfortunately they often contain bubbles, but they are absolutely impervious to moisture and admirably suited to resist wear. The moulding is rough, and many of the bricks are spoilt in manufacture.

Glass bricks have also been occasionally cast in a somewhat similar manner, for use where translucency was required, but they are too slippery for paving purposes and too smooth to adhere to the mortar in walling.

Fixing blocks are bricks made of a soft breeze concrete, into which nails can be driven for the attachment of joinery. They have the advantage over wood plugs of being non-inflammable, and should consequently be preferably used in chimney breasts and other positions where wood plugs might be liable to catch fire.

Terra-wode brickwork consists of burnt clay, in which cork dust or some such substance has been mixed, with the result that it has been burnt away in the kiln, leaving a series of small cavities. The resulting brick is very light in weight, while the cavities render it sound proof, making it a useful material for single-storey partitions under many circumstances, especially as it is comparatively fire resisting, while nails can be driven into it as into breeze fixing blocks.

Concrete partition slabs are made by several firms, with the object of obtaining exceedingly thin and at the same time fire-resisting partitions which can be quickly built, while their surface is so smooth that little plastering is necessary. Some of the slabs are rectangular, with a circular hollow through the middle of each, down which steel rods can be run to strengthen the partition if necessary, while the joints are formed in cement grouting. The other slabs differ from these mainly in shape. For both forms the same advantages are claimed.

Text 14. Timber: its growth and structure-natural defects

The timber which is obtained exclusively from trees which are “exogenous” in growth that is, which grow by depositing annually a new layer of material between the previous year’s growth and the bark. Besides this, almost all are “deciduous” (shedding their leaves annually), and not ever-green. When at maturity such trees consist, when seen in cross section, of a series of roughly approximately concentric rings, each graded from a dark to a lighter tone in woods grown in temperate climates having spring and summer, but homogeneous in tropical woods, these being known as “annual rings”, bound to one another by radial lines known as “medullary rays”; both of which are more or less distinct, according to the nature of the timber and the circumstances under which it has been grown. Of the annual rings, the central rod is known as the “heart”, and, together with the rings which lie nearest to it, is rarely if ever found to be straight, on the wood being cut lengthwise, even in the best and straightest timber cut from straight and apparently uniformly tapering trunks. This is due to its having originally formed the sapling, easily bent and twisted, and not stiffening into regularity of form till near maturity, when compensating growths have taken place to produce external uniformity. It is this heart which first decays in the living timber when maturity has been passed. The rings lying nearest to the heart, known as “duramen”, or heartwood, alone are, properly speaking, those of fully established timber; and these are easily distinguished and sharply divided from the outer rings of “laburnum”, or sapwood. Outside the sapwood occurs a single thin ring of soft material known as the “cambium layer”, which is protected from injury by the bark. If this layer is exposed by removal of the bark, so as to prevent its functional action, the tree dies. The rings nearest the heart are almost invariably thicker than those near the bark, the change being gradual across the section. The annual rings consist of innumerable closed cells not longitudinal tubes and the transference of moisture can only be effected by absorption through the cell membranes, while solids cannot be absorbed at all except in solution. In spring an upward transference of moisture takes place, from the roots, in the sapwood, in the form of crude sap. When this reaches the leaves it parts with much of its moisture by evaporation, and the sap thickens by a process known as transpiration. The leaves, by an elaborate process which need not be explained here, absorb carbon dioxide from the atmosphere and decompose it, freeing its oxygen and retaining its carbon, which, by assimilation, is added to the sap. This now descends in the cambium layer, and is deposited as “elaborated sap” to form a new annual ring outside that deposited during the previous year. This change of assimilated food or sap into structure is known by older writers as “metamobism”, and by more recent writers as “metastasis”. Simultaneously with this growth a ring of sapwood changes into heartwood, and henceforth plays no part in the annual transference of liquid from roots to leaves which, however, is not the only function of the sapwood, for in its cells are accumulated during summer and autumn a reserve of material, the superfluous product of assimilation, to be held during the winter for use in producing buds in the following spring. Sapwood containing this elaborated sap is liable to attack by worms or vegetable growth in stagnant air and moisture, and it is consequently now considered best to fell timber in summer, when the rising sap consists of nothing more than water and mineral salts in solution, as obtained from the roots. There are, however, many advocates for winter felling, while the sap is quiescent. These forget, or are unaware of, the presence of the elaborated sap at that period, or else do not recognise the liability to decay which its presence involves; but all are agreed that felling in spring or autumn, while the sap is most vigorous in its movement, should be avoided. Chemically, normal wood fibre varies little from the formula of cellulose. The medullary rays, known also as the “silver grain”are classified as “primaries”, radiating outwards from the heart towards the bark, and “secondaries”, radiating inwards from the bark towards the heart, the latter rarely penetrating beyond the sapwood. They consist of a series of flattened cells lying above one another in rows, and their function is to assist the transference of elaborated sap from the cambium layer inwards. Owing to its structure and method of growth there are certain natural defects which are common to all kinds of timber. These should be avoided or removed, if possible, during conversion for use. Whether timber containing them should be used for any particular purpose is a matter of degree and for the exercise of judgment in each case. Of these, the most serious is the presence of an undue proportion of sapwood. This is not so often an inherent defect in the timber itself, as it is due to immaturity the felling of unripe trees in order to meet an insatiable demand and is so common now amongst European fir and pine timber that it has become difficult to find any which is fit for use in really good work. Such wood is open and spongy in grain, with large annual rings, and generally blue in colour, the sapwood being readily distinguished from the heartwood in almost all cases by the difference of colour. Similar defects are sometimes due to climate and soil; but, whatever may be its cause, open grained, spongy sapwood should be avoided, and for work in which permanence and high quality are of more importance than economy all sapwood should be removed, as it is much more liable to decay than is the heartwood.

Shakes, or longitudinal splits, are common in all timbers, occurring in the growing tree, and sometimes developing and extending during the subsequent process of seasoning. Until the tree has been felled they are undiscoverable, and even then are sometimes difficult to detect, their appearance varying from extremely fine cracks to open, gaping wounds. They occur more at the butt end of a tree trunk than higher up, and in most instances do not extend far. When they do, they militate much against the economical conversion of the timber, and if twisted longitudinally, as is sometimes the case, may render it totally unfit for use. They are of two classes, heart or star shakes, and cup shakes. Of these, the former radiate from or to the heart, occurring along the medullary rays, and the latter form rings round the heart, occurring along the annual rings.

Knots are the roots of small branches, and if few, small and well knit to the stem, are not looked upon very seriously. On the other hand, they break the continuity of the fibres and militate against the strength of the timber as a whole, while their presence may completely destroy the beauty of the grain where it is exposed in high-class joinery. Whether any particular piece of knotty timber is admissible or not is always a matter of judgment, but large or loose knots (the latter liable to fall out) should cause rejection, and so should the occurrence of several small and otherwise unobjectionable knots if close together or forming a ring round the timber.

Rhind galls are more rare. They are caused by accidental injury to the growing tree, which has penetrated the bark and damaged the cambium ring, temporarily preventing growth over a limited area. Subsequent growth, however, covers the wound, which is no more than a local weak spot in the timber. Similar defects, caused by branches having been torn away from the stem or by their being lopped too close to it, so that the wound is eventually covered, may be very serious, especially if moisture has been admitted to the wound and decay set up before it has healed. Decay thus started and enclosed may be conveyed by the sap over an entire tree.

Twisted fibres, as if the tree had grown corkscrew-wise, are occasionally found, and do little harm if the timber be used in the form of masts or poles, but prevent its being cut into planks, whose strength depends mostly upon continuity of grain; and unequal growth, resulting in the annual rings being thicker and less compacted on one side of the heart than on the other, may also lower the value of a timber.

Doatiness is a defect which is rarely seen in timber whenit is first felled, but which, for no explainable cause, will appear in it after and during seasoning in the form of numerous small, dirty-looking spots, which are softer than the surrounding wood. It is a sign of disease, and is very prevalent in the soft and quickly-grown wood from some parts of Northern Europe. Timber upon which this defect is seen should not be used for any structural purpose whatever, as it is exceedingly liable to decay.

Burrs or excrescenes are apparently the unsuccessful attempts at the formation of branches from some individual spot. When of large size they are very valuable for veneers.

Foxey wood is that which is disfigured by dull red stains, the forerunners of decay, and denoting growth in a marshy soil. These stains are generally found round the heart of the tree.

Quaggy wood is that which is grown on loose soil, having the centre full of “shakes” and “clefts”.

Upsets are defects where the grain appears to be partly separated, so that a shaving at that spot would bend to a sharp angle as if broken. They seem to be the result of violent winds on the more exposed trees of a forest.

Cross-grained wood is that in which the fibres are presented endwise or obliquely on the surface. In this arrangement consists the beauty of mahogany and other hard woods.

Fresh wood is that which, owing to the decreased lateral adhesion of the annual layers, has become brittle and short, and has lost such elasticity and adhesiveness of fibre as in the case of the ash, for example constitutes its peculiar excellence.

Cambleted is a term applied to the roots of the ash and some other trees when they are curiously veined, showing a beautiful surface when polished.

Rosy is a rare term, used to imply that the grain of the wood runs in an irregular direction or overlaps.

Curls and feathers are the result of the confused filling in of the space between the forks of the branches.

Dry rot is a disease in timber, occurring after it has been felled and converted for use, apparently infectious, which occasions the destruction of its fibres, and reduces it eventually to a mass of dry powder. It is produced most readily in a warm, moist, stagnant atmosphere. Water, carbonic acid gas, and probably carburetted hydrogen are evolved, and a dusty substance remains. The growth of fungi accelerates the progress of dry rot, but the origin of the disease appears to be the incipient decomposition of the sap in wood, by which the fungi obtain a nidus (nest) for their growth. Doaty timber is exceeding likely to develop it, and so is immature and insufficiently seasoned timber, particularly if inserted in a damp and unventilated situation, such as in ground-floor joists where the site is not concreted nor the space below them ventilated, and in floor boards, and even in wood-block flooring, laid on damp concrete and covered with linoleum. When it first appears, the timber swells and changes colour, and is covered with a cobweb-like fungus, which emits a musty, unmistakable odour by which its presence is generally first suspected. The fungus grows and spreads rapidly, thickening into the semblance of hoar frost and then to the likeness of the outer coating of a mushroom, while finer filaments, like leaves, spread over all adjacent timber and even over brickwork, plaster, and masonry, but only living on and destroying the woodwork, preferring that which is soft, sappy, and unseasoned. Once established, there seems to be no cure for it. All affected parts must be cut away and burnt, and replaced by sound, well selected, well seasoned timber, properly arranged so as to remain dry and well ventilated.

Decay in the living timber commences normally with the pith or heart, and is due simply to old age, being a sign that the timber has passed maturity. In marked examples it results in hollow trunks. It also occurs, however, as has been already noted, where branches have been improperly lopped or torn off, particularly if wet has been allowed to enter the wound. In converted wood, however, it appears generally to attack the sapwood first, and it is greatly accelerated by insufficient seasoning and by exposure to moisture accompanied by heat and want of ventilation; while it is retarded by hermetically sealing the pores either by charring the surface or by periodical tarring or painting, or by any of the preservative processes to be mentioned later. Constant exposure to wet does not seem to greatly accelerate decay, which, however, sets in very rapidly if there be exposure to alternate wet and dry, appearing in such positions as the margin where posts enter the earth, and in window sills which have had window-boxes for flowers close to them for a year or two. In such positions it is frequently called wet rot ; but this seems to be only another name for accelerated senile decay. Except damp and want of ventilation there are not many external agencies destructive to timber used upon land in Europe. There are a few small beetles which will burrow into old wood, making a number of small holes and eating away portions of the material softened by age. These can be destroyed by subjecting them to the vapour of benzine or chloroform. There are also three forms of destructive ants, which prey mostly upon living timber, including the *dusky* and the *yellow ant*, which prefer soft woods, and the *black carpenter* ant, which prefers hard and tough woods. In the tropics, especially in Africa, India, and Australia, the so-called *white ant* is highly destructive. It tunnels beneath the surface of the wood, which it attacks suddenly and in great numbers, and working in silence will entirely destroy even the whole timber work of a house before its presence is suspected. It will not attack the very hardest woods, such as new teak, the heart-wood of jarrah, greenheart, and ebony, while creosoted soft woods are also safe against its depredations. There seem to be no serious enemies to timber immersed in fresh water, but there are several which work in salt water. Of these, the most important is the *teredo navalis*, which prefers clear to muddy water. It is a worm which bores into the wood, mainly along the grain, and preferably in soft timber, greenheart being that which resists it most successfully.

The *limnoria terebrans*, minute in size and resembling a small woodlouse, is also very abundant in British salt waters, and, attacking soft timber in incredible numbers, will rapidly do a large amount of damage. This also is resisted by greenheart and by teak; soft fir has been destroyed at the rate of 3 ins. inwards per annum. It almost always works just under neap tides, and while it is destroying the surface of timber, the Teredo will be attacking the interior.

The best timber is obtained by felling the tree at the age of maturity, which depends on its nature, as well as upon the soil and climate. The ash, beech, elm, and fir are generally considered at their best when of seventy or eighty years' growth, and oak is seldom at its best in less time than a hundred years; but much depends on surrounding circumstances. As a rule, trees should not be cut before arriving at maturity, because then there is too much sapwood, and the durability of the timber is much inferior to that of trees felled after they have reached their full maturity. From what has already been said of the essential difference between sapwood and heartwood, it will be readily understood that no amount of seasoning or drying will convert the one into the other. All the same, the strength of many woods is nearly doubled by the process of seasoning. Hence it is thriftless to use timber in a green state; especially as it is then not only weak, but liable to warp, twist, and shrink while it slowly parts with the contained moisture, as it will do eventually. To a certain extent this liability exists even in well-seasoned timber, fresh shrinkage and sometimes warping taking place whenever a fresh surface is exposed by planing, and warping being experienced if the wood be damped. It is accordingly customary to have joinery worked up and lightly wedged together long before it is needed, that any correction for such changes of shape or size may be made before the work is finally wedged and glued up. Whole logs of timber, if left exposed to changes of atmospheric conditions, particularly to hot sunshine, are very liable to split. They should either be cut up, either into quarters or preferably into scantlings, and set to season; or else be totally immersed in water until this is convenient. All wood darkens on exposure to light, especially direct sunshine.

Good timber should be uniform in substance, with straight fibres and annual rings of regular form and size, smelling sweet when fresh cut, even and bright in colour, with a silky lustre when planed, the strong grain appearing to rise to the surface; and it should be free from large or dead knots, shakes, spongy hearts, porous grain, sapwood, or other defects. Thus it is often specified, but in practice the absence of all defects is rarely to be met with, and discrimination must be exercised, remembering that trees will not necessarily grow to meet the requirements of a theoretical specification. It is often said that narrow annual rings, which betoken slow growth, are a sign of strong timber; but this only holds good for wood of the same botanical species grown under the same conditions of soil and climate. Timber which is woolly under the plane, or which clogs the teeth of the saw in working, is unreliable, while if a musty odour be emitted it is a sign of incipient decay, and a dull, chalky appearance is also a sign of bad timber. Good timber is an excellent conductor of sound. The ticking of a watch applied at one end of a balk should be distinctly heard if an ear be placed against the other end; while imperfections in timber in position can be detected by positive differences of sound produced by tapping. Perfect parts will strike solid, surface shakes will rattle or “answer” to the slightest touch, and deep shakes will give a hollow sound, while live knots will sound short and crisp, dead knots answering faintly or rattling.

Text 15. Timber conversion

At one time, when the timber in general use was either home grown or else imported and purchased by the builder in the form of logs, it was essential for everyone connected with building to understand the principles of timber conversion. Now, however, that most building timber is imported in a ready-converted state, this necessity no longer exists so strongly, save to assist discrimination in selecting ready-converted timber for particular purposes. Longitudinally the shrinkage of timber is so slight that it may be disregarded and generally is disregarded in practice. The timber in old structures will frequently be found to have sagged and twisted and split, but any diminution in length will be inappreciable. On the other hand, transverse shrinkage is considerable. As already explained, the trunk of a tree consists of a number of roughly concentric rings, each representing a year's growth, yet made up of longitudinal fibres forming cells. The annual rings are held together by a radial structure, known as the “medullary rays” or “silver grain”, of a stiff nature, difficult to compress. Thus heart and star shakes are accounted for, by radial splitting parallel to the medullary rays when the wood is called upon to part with its moisture during seasoning, this necessarily resulting in decrease of bulk, while the stout medullary rays resist decrease in diameter. The annual rings have by no means the same power of resisting collapse, and it is upon their weakness in this respect compared with the strength of the medullary rays that most of the phenomena noticeable during seasoning are due.

Take a log which has been cut into four “quarters” by saw-cutsthrough the heart. That upon the right-hand side is “square”, the saw cuts being at right angles to one another. This is its shape when first cut. After the lapse of a few months or a year, however, the appearance will have altered to that shown on the left-hand side, the size having diminished to the extent of the black wedge-shaped portions. The stiff medullary rays will have retained their length, and the diameter of the timber is the same as before; but the annual ring’s will have partially collapsed, bringing the medullary rays nearer together and reducing the circumference. The same laws govern the shrinkage however the timber is cut. An intermediate plank will behave differently, although governed by the same laws. The contraction of the annual rings combined with the resistance of the medullary rays will cause it to warp, becoming convex on the side nearer the heart, and concave on the farther side, which will diminish considerably in width. At the same time the thickness is less affected than is that of the central plank. In the outer plank the warping is still more noticeable, while the reduction of thickness is reduced to a minimum. Thin floor boards are particularly liable to warp in this way, for they are usually cut and are nailed with the side which is nearer the heart downwards. Thus the edges are liable to rise and the boards to separate, sharp ridges being formed. There is no reason why they should not be nailed with the convex side upwards where the floors are to be carpeted; but if they are to be left bare this would soon result in pieces kicking up and from the fact of this happening has grown up the custom of nailing them with the heart downwards. A little consideration would show, however, that this would not happen where a floor was always kept covered, while sharp ridges are distinctly harmful to an overlying carpet. Hard woods, such as oak, teak, etc., show these peculiarities much more markedly than do the soft fir timbers in general use, for they have much more highly developed medullary rays. Such woods, too, are more frequently cut in square sections, and these, obeying the same laws as have been already explained. This is often noticeable in oak posts; and perhaps the effect is worst when a circular post has been cut out of such a "quarter", as it soon loses its circular shape and becomes elliptical. Hard woods are, however, not infrequently cut. This is generally done for the purpose of exposing the medullary rays, for decorative effect, but, beyond this, warping is prevented though the thickness is reduced, in verted to show the process of seasoning. Another advantage Rays U ary is so secured, inasmuch as experiment shows that timber cut in this way has greater strength, when employed as a beam, than if otherwise cut; and this is to be expected from the fact of the stiff medullary rays occupying a vertical, or nearly vertical, position in the beam, while the stronger annual rings which occur near the heart are kept in compression, and the weaker outer rings in tension. In the conversion of oak and other ornamental hard woods, the method to be pursued would vary according to the purposes for which the timber was to be used. If it be wanted for ornament mainly, the logs would be cut so as to show the peculiar grain or figure of the wood to the best advantage. Thus, after the log has been "quartered", either of the methods, A, B or C could be used to display the silver grain of oak, while the method shown of converting the fourth quarter, D, might be used for the production of thick stuff for constructional purposes. Oak logs cut through the heart, and then with the corners removed, are known as "Wainscot", from which wainscot boards are obtainable, as shown in the illustration. On the other hand, the soft pine timbers are generally converted with little regard to anything save obtaining the greatest possible number of marketable sizes out of a given log. An effort is, however, made to expose the heart, at any rate in the larger scantlings and higher grades of timber, four deals being generally obtained from each log, though a thin board including the heart ought to be entirely removed. Of these, the outer deals necessarily consist almost entirely of sapwood, and are liable to warp; besides which there is considerable likelihood of their running out beyond the bark in places, if not throughout their entire length, and so presenting what are known as "waney edges". In fact, only the inner deals from the larger trees consist entirely, or almost entirely, of heartwood, and so these alone are suitable for high-class work. Unfortunately there is a great demand for quite small scantlings of immature and inferior timber. It consequently pays best to cut European for long before it has reached the sizes mentioned, very small stuff being cut from very young trees consisting almost entirely of sapwood.

It may be remarked, however, that the terms *log* and *plank* are by timber merchants now reserved for hard-woods and for American white-wood, all imported sawn converted timber, cut from pines or firs, being classed as *balks, deals, battens*, and *boards*; or, if planed, as *planed joinery boards, flooring, or matched boards*. There is a distinct difference between both the width and the thickness of ready-prepared timber as ordered and as supplied by the amount of wood removed by the planing machine; and in tongued boarding the width of the tongue also has to be accounted for. This is a trade custom, and has to be accepted, though it would be easy to make the necessary allowances before conversion, and so supply exactly what was ordered. The following table shows the loss, and also, in another column, tells us how many feet run of the nominal size are sold as a “square”, while as a rule a much larger quantity is actually needed to cover a “square” of 100 ft. super. Floor boarding ought to be cut, the boards A, B, and C being properly cut, and all the rest of the log removed for other purposes. That is, the boards should as nearly as possible be cut radially from the centre of the log. Many of the more beaut fully figured hard woods and sometimes the soft woods also, especially figured pitch-pine are also cut into extremely thin slices, called *veneers*, which are carefully glued upon the face of straight-grained wood and then polished. Owing to their thinness, these veneers can be bent round most mouldings, and the effect produced is the same as if the more expensive wood had been used entirely; which as a rule would not be possible, for the twisted grain of the highly ornamental woods renders them so liable to warp and twist as to make their use out of the question unless they are backed by straight-grained wood. It may be noted that if one side of thin wood be veneered the other side should be veneered also, else bending will surely result. Not many years ago all timber was imported in log and sawn in a saw-pit. Two men were employed, one working in the pit below the timber, and the other above it, each holding one handle of a long two-handled saw. Lines were first marked on the log, and these had to be followed by the sawyers, else twisted planks of unequal thickness were the result. At the present time power sometimes steam and sometimes electricity is always used to drive the saw; and it is the timber which travels to the saw, and not the saw to the timber. For single cuts, a circular saw is used, accurate thickness being obtained by keeping the timber against guides as it reaches the saw, which works with great rapidity. If the timber be wanted for flooring, match- boarding, or mouldings, it goes on to other machines, which plane its faces, and, if necessary, plough any grooves or cut any mouldings, at a speed utterly unapproachable by hand. Hard-wood or pitch-pine logs of any considerable size are, however, often dealt with by a saw having several vertically reciprocating blades set at the desired distances apart, all of which work simultaneously; and although the rate of travel is not so great as it is to the circular saw, this is more than compensated for by the number of blades employed. These reciprocating saws, being but a development of the vertical hand saw, require a pit to drop into often a basement beneath the sawing floor which serves for the collection of sawdust. Attention cannot be too strongly drawn to the fact that, owing to the small size of the timber felled, and to the method of conversion adopted, scarcely any fir timber is procurable “free from sap”. The phrase is used in most architects’ specifications, but has been held at law to mean “reasonably free from sap”, and this permits the use of timber of which as much as 50%, may be sapwood. If timber is really required to be free from sap, it must be specified as “absolutely” free from it, and to obtain such timber the imported wood must generally be cut down in an English saw-mill and the sapwood sacrificed, at considerable cost.

Text 16. Timber seasoning and preservation

Timber produced from a newly-felled tree, whether it be heartwood or sapwood, is full of sap, and if this is not properly extracted by drying or seasoning the wood will shrink, warp, and shake after it has been placed in position. The most obvious effect of seasoning is the reduction of weight, which varies with different timbers, and is carried to a different extent according to the purpose for which the timber is required. The following table must accordingly be accepted as approximate only, the degree of seasoning which is sufficient for carpenters' work and common purposes being by no means satisfactory for framed work and high-class joinery. Logs ought to undergo considerable preliminary seasoning before being cut into scantlings, but as pine and fir timbers are not imported in logs, no control over this can be exercised in England in their case. Home-grown timber, however, such as oak, elm, and beech, and imported hard woods as well as American white-wood, which arrive here in logs, should be, and practically always are, thus treated. The *natural process* is generally used, but water seasoning is occasionally preferred. For instance, it is stated that Elm felled ever so green, required for sudden use, if plunged four or five days in water (especially salt water) obtains an admirable seasoning, and may be immediately used, but owing to its great shrinkage is only suitable for purposes where it will be entirely submerged. After conversion the scantlings should be further seasoned, and as a general rule it is at this stage that the principal seasoning is performed, generally by the *natural process*, but frequently by one or other of the several artificial processes known, of which some will be described, though new ones are being constantly introduced, being usually dropped again after a short trial, either on the score of expense or of inefficiency. Still further seasoning is necessary for good joinery work after it has been planed and lightly wedged together, that the final shrinkage may take place before firmly wedging and gluing; while floor boards should, if possible, only be tacked down for some months, and then taken up, clamped tightly together, and firmly nailed. However well seasoned timber may be, it will certainly warp and twist if introduced into an unfinished, damp house. Natural seasoning is carried out by merely stacking the timber, preferably under cover, so as to protect it from rain, wind, and sun, in such a manner that air can circulate freely round each piece. The stacking ground should be paved, or at any rate dry, covered with ashes, and free from vegetation, and the lower tiers of timber should be raised from it on carefully levelled bearers, to prevent the timber from acquiring a permanent twist. Exposure to fierce sun-heat is also particularly to be avoided, as it causes fine cracks to open. There are several methods of stacking; while boards are also frequently stacked vertically or nearly so, and logs are generally stacked with the butts outwards, the inner ends being slightly raised and packing pieces inserted, so that any particular log may be withdrawn without disturbing the whole stack. The time required for natural seasoning is considerable, and varies according to the nature of the wood, the size of the pieces, and its condition before seasoning, while it takes nearly half as long again in the open as it does under a sheltering roof. If proper precautions be taken against warping and splitting, no process of seasoning is superior to this. Water seasoning is frequently used where there are handy ponds or pools of running water, especially for log timber before conversion, in order to hasten the subsequent processes.

It consists in chaining the timber under water, preferably as soon as it is cut, but more often after its arrival in England from the country of its growth, and leaving it thus, with the butt end up stream, for a fortnight or longer (often for several months if it is not required sooner for use), that the sap may be washed out. For this to be effectual, the timber should be entirely immersed, though frequently the wood is merely allowed to float in stagnant water, injuring it along the water line, and merely soaking the submerged portion, without there being any movement to assist removal of the sap, while stagnant water is also frequently discoloured, and stains result. When properly done the process of seasoning is materially hastened, careful drying in the open air following the water seasoning; but while it is rendered less liable to warp and crack owing to the lesser period of air seasoning, its strength and elasticity are said to be impaired. This is less noticeable if salt water be used, as it frequently is in harbours; but for building works salt-water seasoned timber is scarcely admissible, on account of its liability to attract moisture. Timber which, in its country of origin, has been floated to the coast, may be said to have been partially water- seasoned before importation. Such timber, like all other which is water-seasoned, must be thoroughly dried before use, else it will be exceedingly liable to dry rot. Water seasoning can be quickened by using boiling water or steam, but this is rarely done, as it is expensive and tends to reduce the strength and elasticity of the timber. Steaming is, however, employed for the purpose of enabling timber to be bent to any particular shape, and as it effects the seasoning at the same time, nothing more than careful drying is afterwards required to fit it for immediate use. About an hour's exposure to steam is necessary for every inch of thickness. A considerable amount of timber, especially pitch-pine from the Southern States of America, is "stoved" before it is imported into England. This may not be very scientifically done, but it is so far effectual that it prevents the sapwood from turning blue, and renders it extremely difficult to detect the difference between sapwood and heartwood. The application of heat is of no harm if the temperature be under 120 Fahr. Precautions must, however, be taken against the pieces twisting, and in rapid seasoning against their cracking radially; and above all in seasoning at such a high temperature that strength is taken from the wood, leaving it short and brittle. This occurs most markedly if the heat be applied without a current of air. On the other hand, properly performed, hot-air seasoning, besides being rapid, has the added advantage of driving away all valueless matter, the albumen in the timber being made insoluble and the fibres strong and rigid. The timber is carefully stacked in the chamber A, which has a perforated floor B, beneath which is a horizontal coil of steam pipes, supplying the necessary heat. Dry air is admitted by the perforated pipe C along one side of the bottom of the chamber. As it passes through the chamber it becomes charged with moisture from the wood, and is then drawn off by means of a fan through the perforated pipe D, which is suspended along the top of the opposite side of the chamber. Thence the moisture-laden air is driven over a coil of pipes in which cold water is circulating, in a small closed cylinder The moisture condenses on these pipes and is carried away, while the dried air is passed along to enter the pipe C again. This is continued throughout each day, but is stopped at night-time, so as not to keep the timber constantly under tension; and a regular temperature of 105 Fahr. is maintained. When freshly-sawn timber is inserted in the chamber, however, open steam instead of dried air is admitted into the chamber for the first few hours, in order to dissolve the sap and make it more easy to deal with. Freshly-cut oak, one inch thick, takes between three weeks and a month to season by this process, which is hardly applicable to large scantlings, while the length is limited by that of the chamber. If the rate of seasoning be forced, either by quickening the flow of air or raising the temperature, or by keeping it going constantly night and day, the result is not satisfactory, a hard and brittle surface being produced. It may be pointed out here that stoved or desiccated wood is liable to reabsorb moisture from the air and return to its original unseasoned condition. If used for joinery, it should consequently be kept in a warm drying room between the times of being worked up and being finally fixed, and should be painted before fixing, preferably before leaving the drying room, and certainly before insertion in an unfinished, and consequently damp, house.

Exposure to the products of combustion of a fire, in a chamber which contains a large surface of water is in principle much the same as desiccation, the result being to make damp, warm air circulate amongst the timber. Efficiently performed, it is equally good, and it is somewhat largely used. It is said that this process renders timber harder, denser and tougher, while entirelypreventing dry rot, and that it is best to treat the wood in as green a state as possible. If the heat applied be not too great, sound timber will neither split or warp in the slightest degree, and at the same time thorough seasoning takes place; while subsequent exposure to the atmosphere will not result in any material absorption of moisture at any rate to not the same extent as happens after dry air seasoning.

SMOKE-DRYING. Occasionally the seasoning of timber is hastened by drying it over a bonfire of straw, shavings or furze. This is said to render it proof against the attacks of worms, and to make it hard and durable; but the process is rough and somewhat elementary, and is likely to lead to the timber splitting if the heat is not applied very gradually so as to dry out the moisture from the interior.

PRESERVATION BY PAINTING, OILING, TARRING, OR CHARRING. The best seasoned timber will not stand exposure to weather in England for more than 25 years unless some further means be taken to preserve it, and although oak in a dry and well ventilated position has been known to last a thousand years, it is customary to paint all exposed timber in ordinary building works. The effect of painting is merely to cover the surface with a thin film which is impervious to moisture, but as paint is itself perishable, it needs to be renewed, generally once every three years if exposed to the weather. This preserves timber for a very long period, provided that it has first been thoroughly seasoned. This is a very important point, for otherwise the filling up of the outer pores only confines the sap, and so leads to decay. In such a case, it is usually the sapwood which decays first, but properly seasoned timber, whether it be sapwood or heartwood, seems to be equally well preserved by painting. Oiling and tarring have precisely the same effect as painting, save that tar is less perishable than paint and rarely needs renewal, except where it is exposed to sun-heat. Tarring is consequently much used for timber which is inserted in the ground or placed close to the ground and out of sight, and for hidden ends and bedded surfaces of timber in constructional work; but its rough and unfinished appearance, its stickiness when exposed to heat, and its inflammability render tar unsuited to many positions. Charring also may be classed with painting and tarring, it being applied to the surface of timber where it enters the ground, with the object of closing the external pores in this instance permanently.

CREOSOTING. Many processes for preserving timber by impregnating it with various substances have been put forward from time to time, but the only one which has proved to be practically and commercially successful is that known as Creosoting. Commercial creosote is a dark brown, thickish liquid obtained from coal-tar, of which it constitutes from 20 to 30%. It consists of the light and heavy oils of tar, and is produced from coal-tar by distillation, at temperatures ranging from 350 Fahr. up to 760 Fahr. Its com- position is very variable, and but little appears to have yet been accomplished in the way of fixing any standard of purity, or of recording the complexity of its many constituents. The timber to be treated should be thoroughly well seasoned, and then artificially dried for 24 hours. It is then piled in a cylinder, which is closed airtight, and pumped to a vacuum. Creosote at a temperature of 120 Fahr. is now allowed to enter, and after the cylinder is full pumping is resorted to at a pressure of 120 Ibs. per square inch. The creosote should be such as to be entirely liquid at 120 Fahr., should contain not less than 25%, of constituents which do not distil over at 600 Fahr., and should yield to a solution of caustic soda not less than 6%, by volume of tar acids, while the specific gravity at 90 Fahr. should lie between 1*040 and 1*065, water being roo at the same temperature. The process is exceedingly efficacious for soft woods, and is invaluable where these are employed for fencing, piles, railway sleepers, or the paving of carriage-ways; but the discoloration produced and the strong odour of the creosote make it unsuitable for use in ordinary building work. Sapwood in particular is improved by creosoting; but there are several of the hard woods, including pitch- pine, which the liquid cannot penetrate.

NON-FLAMMABLE WOOD. Many processes have been put forward for the preservation of timber from fire, with little success till recently. One, the chemicals employed in which are not revealed, has of late years proved successful, and not only renders the wood highly fire resisting, but has the further advantages of seasoning and drying it at the same time within a month of its being felled if necessary while the chemicals used are antiseptic, odourless and harmless, and do not injure the wood. The timber to be treated is stacked on low wheel trollies running on tracks laid from the stacking yard into the treating retorts or cylinders, which are 105 ft. in length and 7 ft. in diameter. The loaded trucks are then run into the treating cylinder, more or less trucks being employed according to the quantity of timber to be treated, and the door of the cylinder closed. The load is now subjected to changes of temperature and certain manipulation, by which means the volatile and fermentable constituents of the wood are withdrawn and the pores of the wood prepared for the reception of the fireproofing ingredients. When the timber is ready, the latter is presented to it in the form of a solution of a certain definite strength, such strength varying with the description of wood under treatment. Hydraulic pressure is next applied until the wood is thoroughly saturated. The cylinder is then opened and the load withdrawn, which, if the cylinder be full, will consist of 20,000 cubic feet. The wood, now thoroughly saturated, and, consequently, more than double its original weight, is re-stacked and run into the drying kiln, which is a large room fitted with heating apparatus, and air fans to circulate warm currents of air, and condensing apparatus to condense the vapour arising from the wood. In about thirty days a load of wood of average thickness should be dry; that is, the aqueous portion of the solution has been drawn off, leaving the fireproofing ingredients closely incorporated with the cellulose in the pores of the wood. The wood is now ready for delivery, and, owing to the fact that the volatile and fermentable constituents have been driven off and their place filled with antiseptic material, no rot can take place. Besides, as the wood has been equably dried, the possibility of after-warping is avoided; and since the interstices of the wood are packed with material, no after-shrinkage is possible.Some woods lend themselves more advantageously than others to the process notably the open-grained non-resinous woods; while those woods that contain large quantities of pitch and resin, such as pitch-pine, and woods that are very oily in their constituents, such as teak, prove to be sometimes more or less refractory to the treatment. Woods of this class after treatment, while liable under conditions of very intense heat to inflame, are most difficult to ignite, and consequently afford a protection against fire far greater than if the wood was untreated. In the case, however, of non-resinous and non-oily woods, where complete impregnation can be effected, the treated wood is said to effectually and permanently resist the spreading of flame.

Text 17. Timber classification

All building timber may be broadly classed under two heads, *soft woods* and *hard woods*; the terms soft and hard, however, being used in a very general sense, some of the so-called soft woods being harder than some of the hard woods. This comes about through the term soft wood being applied, as a popular name, to all timber of the natural order of Coniferce that is, to all timbers which in their growing state are cone bearing, and have spikes instead of leaves all others being known as hard woods. The following classification of timber is now accepted:

Class I. *Soft wood or pine wood*, having very distinct annual rings, one part of each ring being hard and dark and the other soft and light coloured, while the pores are filled with resinous matter. Pine, Fir, Larch, Cowrie, Cedar, Cypress, Yew, and Juniper all belong to this class.

Class II. *Hard wood or leaf wood*, the various examples of which may be subdivided. When more detailed classification is attempted, however, the confusion which exists in nomenclature introduces an element of extreme difficulty, which is accentuated by the fact that, in the ready-converted form, it is often almost impossible to distinguish between even botanically different timbers, to say nothing of botanically similar timbers sold commercially under different names and shipped from different ports. This is especially the case amongst the soft woods, which are almost exclusively used for ordinary building work to such an extent that the great forests of Northern Europe have been nearly denuded of well-grown timber, so that large balks, free from sap-wood, are hardly obtainable; which is scarcely surprising, considering that a well-grown pine tree takes from 180 to 300 years to reach maturity, according to climate, and that the slower-grown timber is generally the best.

The following pseudonyms for the general classes of soft woods may be here noticed: North America is much more rich in varieties of fir timber fit for building purposes than is Europe, and as a general rule the American timber now imported is superior to the European, although the effect of reckless felling is being felt, and large sound timber is not always easy to obtain. Much of the

American wood is, in its converted form, almost indistinguishable from the European, however, save by the system of branding and the marks adopted; so that one is frequently substituted for the other. On account of confused nomenclature it is again desirable to adopt a tabular system of classification, the same timber being frequently known by several names, and, at least in the case of pitch-pine, several different timbers being known by the same name. In each case the first name given will be that in most common use in England. Formerly sound wood of good length and scantling. Not many large trees left. Still excellent timber if obtainable free from sapwood. Suitable for good carpentry. Even the first quality cut with much sap-wood, often with the heart contained and sometimes shaky, while small scantlings are commonly all sapwood. The lower qualities are mere rubbish. No timber of any value.

The only soft wood calling for notice here is the New Zealand Kaurie pine. It is a soft, clean wood, straight in grain, and somewhat like the Canadian Pinus Strobus in working and uses, being large and free from knots, and consequently suitable for joinery; but the forests have been somewhat wantonly cut, and the timber cannot be replaced, as it is exceedingly slow growing. It shrinks very little after seasoning, and takes a polish. The extreme confusion which exists in the naming of all soft woods has led to the suggestion of the adoption of the following specification, in which the botanical instead of the popular names are used. If beyond the comprehension of a few, it is not more so than in the existing uncertain naming, while it has the merit of being at least exact. Best floors to be of mid-Swedish Pinus Sylvestris, and other floors of Russian or North Finnish Picea Excelsa. Joinery where exposed to weather to be of Pinus Sylvestris, from the White Sea. Other joinery to be of Canadian Pinus Resinosa or Russian Pinus Sylvestris, with panels of either Canadian Pinus Strobus or Russian Picea Excelsa. All is to be completely free from sapwood, pith, loose or dead knots, and twisted grain, and is to be sawn die square. Soft timber, having straight grain with slight cohesion between the fibres, should be used in straight pieces. Allowance should always be made for shrinkage; panels, for instance, being allowed freedom of movement to prevent splitting. Joiner’s work should be made and lightly put together long before it is wanted, being only finally glued up after the initial shrinkage has taken place. In constructional work, timber may be used under direct compression, tension, or transverse stress; but it is not suited to resist shearing along the grain. Where this is unavoidable the joints must be very carefully made. Mouldings should not be undercut, nor should there be any other than simple carving in soft woods. All timber must be kept dry and well ventilated, or else preserved by careful and frequent painting.

The hard woods are fortunately free from the extreme confusion in nomenclature from which the soft woods suffer. Each has one scientific and one popular name, although many of them have several varieties. Oak is unquestionably the most important of the hard woods grown in the temperate zone; though it must be acknowledged that some of the tropical and semi-tropical woods possess such high qualities as to run it very close for many purposes, and to be superior to it in some. It is hard, tough, strong, lasting in air or water, heavy, and obtainable in great lengths and size, and either of straight grain for constructional works, or of most beautiful knotted figure for decorative purposes. The annual rings are distinct, the softer portions being apparently honeycombed, and though the wood is far from porous transversely on account of the hard structure of the cell walls, it is porous laterally along the grain, especially the softer wood grown on loose soil. When cut so as to expose them, the medullary rays are equally distinct, as compact wood with a silky appearance when planed, adding greatly to the beauty of the timber. It may be painted for external use, but is more frequently only oiled, so as to show its rich colour and grain; while internally it may be, and frequently is, used without protective coating of any kind, being left to darken with age, which it does to a rich black. This effect may be artificially obtained by exposing it, after it is wrought and finished, to the fumes of weak ammonia in a closed chamber, the depth of colour depending upon the length of exposure, three days producing a rich mellow tone, only to be reached naturally in some twenty years. This process is known as fumigating. Oak contains gallic acid, which will rust iron fastenings, hinges, etc., which may come in contact with it. Oak thrives in almost any soil except bog and peat, though it prefers a rich loam with underlying clay; and as a rule forest trees are better for conversion than those grown in hedgerows, having a greater length of clear stem. The most beautiful wood for ornamental purposes, both in colour and grain, is obtained from decaying and hollow trees, and this is usually cut into veneers. It is very hard and practically all heartwood. The sapwood is greatly inferior to the heartwood, both in strength and durability, and should be rejected for works of any importance. There are four European varieties of oak, whose timber is practically indistinguishable. With footstalks of acorns long and those of leaves short. Grows all over Europe within the latitude limits. With footstalks of acorns short and those of leaves long. Grows all over Europe within latitude limits. Fruit and leaves as Sessiliflora, but with downy underside of leaves. A somewhat rare timber, and of inferior quality. With richly serrated leaves and mossy cups to the acorns. Found in Southern Europe only. It is very generally thought that English-grown oak is the best, and it is generally specified. This is, however, largely a patriotic prejudice which originated before the better class continental timber of the same botanical species was largely imported, or even known; and as a matter of fact true English-grown oak is rarely supplied. That from the Baltic, Spain, and Austria is equally good, there is very much more of it, and it is cheaper, Austria (including Hungary), especially having immense oak forests which can be regularly and commercially worked, while our own oak is only spasmodically grown. Three different varieties of oak are imported from the American continent, and these are of unequal quality.The

Baltimore and Canadian oaks, the only two to which valid objection can be raised, have been largely imported of late, and are now those which are generally called “American Oak”. They are not difficult to detect, owing to their small annual rings, and to their turning red in colour if kept covered up for a few weeks. This does not occur with the Quercus Alba, which is equally an American oak, but to which there can be no objection. Oak is largely used where rough usage is expected, as in the treads of stairs; where liable to exposure to damp, as in window sills; in heavy constructional works, and wherever shocks are to be expected; and also for durable carved work, for which scarcely any other wood is suitable; and for high-class joinery of all descriptions.

After oak, mahogany ranks highest amongst the hard woods used in building, and deservedly so it can be used with advantage for almost every description of high constructive and decorative work. The range of sizes and quality, the variety of colour, and the diversity of figure is extreme. Thirty feet is not an unusual length, and the squares range from 12 ins. to 50 ins. Much of it is firmly-grown wood, North latitude but generally moderately hard and from the east from 25 1040 compact, tough, coast of the ft. long, and strong, and fairly United States from 15 to 28 durable. Planks canto the State ins. thick. be readily bent when of Illinois. steamed without fear of splitting them. A very sound wood. Very slow growth and soon decays, unless well protected from weather. Canada and straight timber of large what porous, and States Logs easy to work. No vary from great strength or 25 to 50 ft. durability. Very slow long by 12 growth and small to 24 ins. annual rings. square. not too difficult to tool; it seasons readily with an absence of splitting and checking; it does not warp, and is practically non-inflammable; and it is capable of receiving a high polish, while as a ground work for paint it is without an equal. For ornamental purposes it is considered defective in colour when its paleness approaches that of birch, and it may even be too highly coloured, but the best is of a bright ruby appearance. Wood of good quality, firmly grown, is non-porous, and should be fine and free in working, and not too hard. The various figures in the grain are known as “roey”, “motley”, “fiddleback”, “plum pudding” and “curly”. Much that is imported, however, especially that from Africa, is almost free from figure, and even from grain, the annual rings being difficult to distinguish, and if light in colour, as it frequently is, it is then quite inexpensive, and highly valuable for all constructional purposes, especially for sound joinery which is to be painted. The figured varieties, much more costly, are reserved for polished hand-rails, bath-casings, shop-counters, w.-c. seats, etc. All should be thoroughly dried before use. True mahogany grows in the West Indies and Central America, and is a large, handsome tree. Popularly it is known either as “Spanish” (Cuba, Trinidad, San Domingo); and as “Bay Mahogany” if it come from Honduras. The differences are difficult to detect, although the “Spanish” is the colder to the touch, and has an extremely silky texture with white specks in it the specks in “Bay” wood being black. For decorative purposes the Spanish is undoubtedly best, having the finer texture and possessing in the more marked degree the property of mellowing arid improving in colour with age. The import is, however, diminishing. Much excellent wood of larger size is now being sent over from Tabasco; while smaller, and generally inferior, shipments are also made from Mexico and Panama. African Mahogany is shipped from almost all ports on the West Coast of Africa. The quantity received is simply enormous, representing the product of different districts. The wood of each has its own utility, but probably the following classification will meet approval. Lagos wood, in colour and silkiness of texture, more closely approximates to the Tabasco shipments, but in size it is generally small. Benin wood affords an excellent range of sizes, and the logs are well squared. The wood, having a splendid texture, commands a leading position. Axim and Assinee wood is usually well squared, and yields enormous sizes; the colour is generally good, but the texture is softer than other shipments; it is also found that the logs are more or less liable to cross fractures, which cannot be seen until the logs are cut into. Bathurst wood represents the hardest mahogany from Africa, but the sizes are somewhat small. There are other African ports from which good merchantable timber is shipped, which, however, does not require any special notice; but Gaboon wood is very little better than birch in colour and texture, and, as a furniture-wood, it should be avoided. Sapeli wood comes in fine, large, well-squared logs, but is scented like cedar, the colour and texture being extremely variable; it is certainly not growing in favour with buyers, some of whom doubt if the wood is in reality a mahogany. Teak, while of less beauty than oak or mahogany, is a wood of extreme value, steadily growing in favour. Whilst it is not difficult to tool, it contains an essential oil which renders it imperishable. As it resists the alternations of damp and dryness, heat and cold, there is in it an absence of swelling and shrinking or warping, so that in high-class work there is hardly any purpose to which it could not with advantage be applied. Its general uniformity of colour and grain is unique. Considering the many high essentials found in teak, and the remarkably fine sizes obtainable, both in logs and planks, and the freedom from defects in the latter, it is by no means a dear wood for good work. The logs imported vary from 23 to 50 ft. in length and from 10 to 30 ins. square. It is of a dark reddish-brown colour, with strongly defined grain, and is very heavy. It darkens with age, becoming almost black, while when first felled the heartwood is of a dark golden yellow. It is certainly the best weather resisting wood known. In small pieces it may sometimes be mistaken for mahogany and sometimes for oak, but in large pieces it is unmistakable once seen. The essential oil which it contains acts as a preservative of iron fastenings; but it sometimes congeals in radial shakes, forming a hard substance which no edge-tool can touch without losing its keenness. Teak logs are always heart-shaken.

Besides those already mentioned there are no hard woods which are at present largely used in building operations, although there are several which, owing to special qualities either of strength, size obtainable, colour or beauty of marking, are occasionally employed. These may, perhaps, be best arranged in alphabetical order in tabular form, to render reference easy, special attention, however, being called to the Australian Eucalyptus timbers, Karri and Jarrah, which are rapidly growing in favour for many purposes.

Must be used fresh cut, certainly within a year. Most durable if kept entirely dry or entirely wet. Soon decays if subject to changes above. Takes good polish. Warps and twists in drying lean and straight in grain, very heavy and tough, hard, strong, and elastic. In transverse section it looks like cane, being full of minute pores, with annual rings hardly visible. Dark greenish colour; centre often nearly black. Sap and heartwood difficult to distinguish 'hite colour, close, hard, tough, and strong, with minute pores and plainly marked medullary rays Contains no heartwood tard, coarse grained, and beautifully mottled, showing wavy fibres on radial sections. Dark brown, inclining to red. Contains much resin. Weighs 60 Ibs. per c. ft. as "Ironwood" in different parts of Heartwood is bright red, streaked brown and black; snpwood a greyish colour, and very narrow. On exposure to light the heartwood turns to a clayey brown Soft, easily worked, no durable. Twists in seasoning. Tangential sections show medullary rays. Satiny lustre. Not a handsome wood Heartwood is hard, close grained, very dark purple, streaked longitudinally with black; sapwood yellow, forming a narrow ring Heartwood hard and dark brown A remarkably solid wood, with very little sap, and almost entirely free from shakes. Stands exposure well. Liable to contain hidden cross fractures of the fibres Yellowish-brown heartwood, strongly scented. Half the diameter is sap-wood, white and scentless. Close grained and compact, but not strong. Takes a polish, but shrinks and warps in seasoning.

Hard woods, having much greater cohesion between the fibres than soft woods, may be used in curved as well as straight pieces. Shrinkage is complicated by the action of the medullary rays, but is generally less than in soft woods. In constructional work, hard wood should always be used where subject to shocks, as in warehouse doors and storey posts. Mouldings may be undercut, and carving may be rich and deep, there being ample cohesion to render this possible. Exposed hard wood may be protected by oiling, varnishing or polishing; but so long as it is kept dry and well ventilated it is exceedingly durable even if unprotected.

Text 18. Iron ores and their reduction

Much of the iron ore now used in England is imported from Spain, the richer veins of English ore being mostly worked out or nearly so, that which is left having so small a yield of metal as to be unprofitable. The different kinds of ore and the localities in which they occur, or used to occur, are as follows: A carbonate of iron, of clay-like appearance but oolitic structure, with nodules the size of a pin's head in a silicious envelope. Very impure, containing clay, pyrites, and sulphur. Clay ironstone containing 15 to 20% of bituminous and carbonaceous matter, and consequently easy to smelt. Oxide of iron, generally in globular or kidney - shaped masses; red in colour. Crystallized carbonate of iron, generally mixed with lime. The most important English ore which is now profitably worked is that from the Cleveland Hills, near Middles-brough. The best seam, 10 ft. thick, yields 30%, of iron, but this is largely worked out, and much now being smelted yields only 26%. As the cost of reduction rises as the yield diminishes, the limit of profitable working must soon be reached. At the works the ore is first tipped, together with small coal to act as fuel and limestone, in such proportion as is later on required to combine with the impurities in the ore, into large continuous kilns, and there calcined, the process being the same as that of lime-burning. Coke is similarly tipped into bunkers adjoining the kilns. This roasted ore and limestone and coke is next hoisted to the top of a blast furnace and tipped over its edge into a deep circular V-shaped hopper formed between inwardly inclining plates of C.I. and a central steel cone suspended from a chain by a counterbalance. When enough has been tipped into the hopper, together with a proportionate amount of coke, the cone is allowed to drop, discharging- all that is lying upon it into the furnace, which is kept full to within about 15 ft. of the top, and is only allowed to go out once in several years, for repairs, it being otherwise in continuous work, night and day. Immediately below the level of the cone is a flue, into which pass the gaseous products of combustion, the valuable part being the inflammable carbon monoxide from the coke, and this is carried off to heat an air blast. This, at a temperature of some 1,500 Fahr., is forced into the furnace near its floor through small nozzles known as "Tuyeres", surrounded with coils of W.I. pipe, through which water circulates to prevent the sides of the furnace well burning out. The furnace is built of brick, much in the shape of a soda-water bottle, witha flat bottom or hearth, which, like the whole interior, is carefully constructed of fire-brick. Under the influence of the great heat some 2,000 Fahr. which is generated, the ore is reduced and melted, the iron which it contains sinking, from its greater specific gravity, to the bottom and resting directly upon the hearth, while a lighter scum of impurities, known as slag, floats above it, the burning ore being above that again. When the molten matter has reached to a sufficient depth, never so great as to rise to the tuyere holes, a hole is opened at such a level as to allow the slag to escape. This, which is a crude glass in a molten state, is passed along a trough, and, though some of it is utilised for paving bricks, and some is blown into slag wool, the greater part is valueless, in waste heaps or barged out to sea and dropped in deep water. After the slag has been drawn off, the furnace is “tapped” by making a small hole in a fire-clay stopping at its hearth level. Molten iron runs out through this hole into a semi-circular channel made to an inclination in a sand bed. With this metal flows some slag, which rises to the surface and is almost immediately diverted along a branch channel, while the iron itself continues its course down the main channel. At the bottom end of this main channel a branch runs off at right angles, which itself has many short branches parallel to the main, each just long enough to hold I cwt. of iron when full, known as “pigs”. When the branch and the pigs which it feeds are full, another branch little higher up the main is opened, by breaking down a temporary wall of sand which lay between, and the main itself is blocked with a C.I. “shutter” just below this newly-opened branch; and so on the process continues unti all the molten iron lying in the well of the furnace has been run out into the pigs. The channels, both the smaller ones or pigs, and the larger ones, known as sows, are formed by laying wooden moulds on layers of sand, lying on a sloped platform, and ramming damp sand into the spaces between the moulds and levelling the surface before the moulds are removed. Initials denoting who are the owners of the furnace, and showing from which furnace of a series the metal is run, are stamped in the sand at the bottom of each pig. When sufficiently cool the metal is roughly broken up into separate pigs and sections of sows. It is brittle and rough when red hot.

MAIN VARIETIES OF IRON: THEIR IMPURITIES, STRENGTH AND TESTS. It will readily be understood that pig iron, as run from the blast furnace, is necessarily impure and irregular in its composition, from the intimate manner in which ore, fuel, and flux have been mixed. The principal impurity is carbon, but there are also generally present, in small quantities, silicon, sulphur, phosphorus, and manganese. So important is carbon that it is upon the proportion of this element contained in the metal that the principal distinction between cast iron, steel, and wrought iron depends. Cast iron contains from 5 to 2%, of carbon; steel contains from 2 to 15%, of carbon; wrought iron contains less than 25%, of carbon.

A. Puddled Iron. Prepared in a pasty, imperfectly fused state, therefore not homogeneous; contains intermixed slag. Varieties containing more carbon are called Puddled Steel.

B. Ingot Iron (Mild Steel). Prepared perfectly fluid therefore homogeneous; contains intermixed slag. The harder varieties, containing more carbon and used for large steel castings, may be called Ingot Steel.

VARIETIES OF IRON: IMPURITIES AND STRENGTH. The effect of imparities other than carbon is worth noting, though of more importance to the manufacturer than the user, who, so long as he obtains a material which will do the work he requires, does not mind much how it is composed. The following table is therefore rather of interest than value to the constructor: Effect similar to that of carbon. Also makes it more fluid when melted, i.e., less viscous. 2%, makes it cool and solidify without bubbling. More makes it brittle. 5%, makes it unforgeable. Makes it hard and brittle. Reduces tenacity, hardens, renders fusible. 1 per cent, makes it cold, short and useless for tools. Most injurious. Injurious, 1%, makes it more weldable. 1%, makes it too brittle for use. Tends to produce white variety. Essential in mild steel to counteract sulphur. Counteracts red shortness. Sulphur Tends to producewhite and mottled varieties. More than 2%, unfits it for forging, but makes it more fluid and suited lor coating. 3%, produces red shortness. In ordinary structural work the following are the approximate data upon which calculations for strength should be based. Ordinary quality, suitable for medium-sized columns, etc., and steady loadings Good quality, suitable for large or light columns, bressummers, etc. Special quality, where sudden shocks or extra stresses may arise, as in beams carrying heavy live loads, machine castings, high pressure pipes, etc. Castings should also be tested by tapping them lightly with a hammer all over in order to detect, by the sound, the presence of any air bubbles, cracks, or hollows filled with the sand used in casting.

Maximum and minimum tension strains are in tons per square inch of original section.

Elongation is the percentage of increase in a length of 8 ins. Contraction of area tests are seldom applied to steel, the elongation being considered a sufficient test for ductility.The following results of a test upon Whitworth fluid pressed steel show, however, that a better material is obtainable when required for special purposes, though the additional expense of producing it is not generally warranted, it being more economical to use more metal of ordinary quality.In breaking a specimen of ductile material, such as wrought iron or mild steel, by tension, it is found that before fracture takes place the test piece behaves as a viscous substance (pitch or toffee), and flows, being drawn out uniformly until a contraction takes place at the weakest point and fracture occurs. The elongation, or extension, which is thus caused is a measure of the ductility of the material; but in judging this quality, regard must be had to the length of the specimen used, as it is found that of two test pieces of the same material, but of different lengths, the shorter will give the higher percentage of elongation; and similarly, After Test being equal, the thicker the test piece, the greater is the percentage of elongation. Furthermore, ductile materials such as these, when subjected to a gradually increasing load, as in a testing machine, carry the load up to a certain point with trifling elongation, and return to their original dimensions on removal of their load. In other words, they are perfectly elastic up to that certain point, which is generally known as their “elastic limit”, or “yield point”. On further increasing the load, however, the material “breaks down”: it begins to stretch to a more marked degree and does not come back on removal of the load. The effect appears to be cumulative. If a load, in excess of the yield point, be applied and removed, stretching occurs, and if the load be applied again, further stretching occurs, with the inevitable result of eventual fracture if the process be repeated too frequently. Consequently in considering the strength of materials for structural purposes, the yield point should be taken as the measure of their tenacity and not the ultimate tensile strength, a point which can scarcely be emphasised too strongly; but ordinary practice is the reverse of this. The use of a sufficiently high factor of safety, and consequently of a sufficiently low working or safe load, puts this right. Repeated alternating stresses, the material being alternately in tension and in compression, have also a weakening effect, even if they be well below the yield point individually, but the nature of this effect is not yet quite clear.

Text 19. Cast iron and casting

When the crude iron is run from the blast furnace into sand moulds, forming pig iron, a portion of the carbon taken up in the furnaces separates out in the form of graphite. Some of this floats to the surface and is removable, but the rest remains incorporated in the iron. Furnaces which work with silicious ores, and with a large percentage of fuel at a high temperature, produce a metal containing silicon, which assists the crystallization of the contained carbon. The result is *grey cast iron*, which displays a grey fracture showing distinct crystals of graphite and a large, dark and bright grain. It is readily fusible, runs well into moulds, and is most suitable for delicate castings, but of no great strength. It is also used for conversion into steel. Where the opposite conditions prevail, of furnaces working with non-siliceous ores, with a low percentage of fuel and low temperature, the resulting metal contains little silicon and the contained carbon does not crystallize. The result is *white cast iron*, having a fracture of silvery hue, hard and brittle, and of little use for castings, except the very commonest, such as sash-weights. It is principally used for conversion into wrought iron. Its specific gravity is 7-5.

Mottled cast iron lies between the grey and the white, or, more accurately speaking, contains both. When treated with nitric acid, the fracture of grey iron shows a black stain, while the stain on white iron will be brown. Grey iron may be converted into white by suddenly cooling it. It is thus rendered brittle and hard, and advantage of this fact is sometimes taken to give a hard surface to a grey casting by embedding massive cold iron in the sand of the mould, so as to be in contact with those parts which it is desired to “chill”.Similarly white iron may to a certain extent be converted into grey iron by reheating and gradually cooling it; but it must be remembered that these changes do not affect the composition of the alloy.

The percentage of sulphur in white iron is generally greater than this. When it is required to confer toughness on small cast iron articles of complex form, they are embedded in haematite and heated for several days, and are thereby rendered malleable.

By modifying the working of the blast furnace, and by the use of different ores, other important forms of crude iron are obtainable, including *ferro-silicon*, a light coloured glazy iron, rich in silicon, useful for mixing with white pigs in the "cupola" in order to produce grey iron; and spiegel-elsen (mirror iron), an alloy of crystalline structure and lustrous appearance, containing a considerable amount (about 10%) of manganese, and consequently more carbon than does the normal pig. When the proportion of manganese is largely increased, up to a possible maximum of 85%, the metal is called *ferro-manganese*. These manganitic pigs are both used in steel making, and so also, to a less extent, are *ferro-chromium*, containing 60 to 70%, of chromium; and *phosphoric iron*, containing as much as 7% of phosphorus. For foundry purposes, pig iron is remelted in a "cupola" this somewhat misleading name being given to a small vertical blast furnace, worked intermittently with a cold blast. It is about 5 ft. diameter interally, and lined with fire-brick. Almost invariably advantage is taken of this opportunity to mix pigs of various classes, with the result that any desired quality of cast iron can be obtained. The oxidation of silicon would occur in this furnace, to the detriment of the casting, were it not prevented by the presence of manganese, which is the first impurity to oxidize when crude iron is remelted; while grey iron, rich in graphitic carbon, is improved by being mixed with poorer varieties when used for castings. The pigs and coke are fed into an upper door from a gallery, are melted in the furnace, falling on to the hearth, where a scum of slag collects and is removed as in the blast furnace, while the molten metal is poured out through a shoot, in appearance like a stream of golden water, into a tipping ladle, whence it is poured into smaller ladles carried by one, two or more men to the moulds. The preparation of the moulds and the process of casting is long, difficult, and often complicated; and it is unnecessary to go into the matter here in detail, though a general description may be useful. In the first place, a pattern or model of the object which it is desired to cast is made of wood, a trifle larger than the finished object, to allow for shrinkage in cooling. Frequently a pattern has to be in several pieces, to allow of its subsequent removal in sections from the sand mould; and often these pieces are alternative where slight variations from a general model are required. For simple castings of small or moderate size, the pattern is placed on its side in the lower of a pair of square frames without top or bottom, known as flasks, so that half of it rises above the level of the top of the flask; and then fine, loamy sand in a damp condition is tightly rammed into the flask round it. The surface of the sand is smoothed level with the top of the flask, and sprinkled over, together with the visible half of the pattern, with dry or “parting” sand. The upper flask is then lowered so as to fit upon the lower half, to which it is bolted, and damp sand is again packed in, over and around the pattern. When full, the upper flask can be lifted off, carrying with it the tightly-packed damp sand which it contains, but not the dry parting sand nor the pattern, which can be lifted out carefully. For many purposes the flasks are dispensed with and the pattern is sunk in the floor of the foundry, and there packed round with sand or even roughly built in with brickwork before the sand is packed; while for special purposes specially shaped flasks are used. In either case, the mould left on removal of the pattern frequently requires touching up and finishing by hand an extremely delicate operation; and when sharp castings are needed it is dusted with powdered charcoal and carefully smoothed. This also prevents the iron from being chilled by too close contact with the damp sand, as a cushion of gas is formed when the metal is poured in. Finally, holes are carefully rnade through which the contained air of the mould and any produced gases may escape, and for the pouring in of the metal; the flasks are closed; and the metal is poured in great care being exercised in the case of large castings, where more than one ladle of metal is used, that the pouring is continuous; and if more than one pouring hole is used, that two streams of metal shall not meet when in the smallest degree cooled; otherwise a weak spot, or joint, known as a “cold-shut”,will be produced. As bubbles form and rise to the surface during casting, it is well that the metal be poured in to the very top of the mould, and that a “head” of metal, afterwards to be cut off, be cast, into which such bubbles may collect. Hollow objects, such as columns and pipes, have to be cast round a solid core, which frequently itself consists of a pipe perforated with many holes, round which damp sand is carefully worked to the desired shape. Theoretically such objects should be cast vertically, but this is rarely possible, and they are generally laid to a slight inclination and cast with a head. The core is, in large columns and long pipes, difficult to fix and retain in position so as to give uniform thickness of metal throughout. Often the core is connected to the outer sand of the mould with iron wire or nails, which, when the hot metal is poured in, are firmly embedded in it. Castings should be left in the sand mould to cool gradually, else irregular cooling is likely to occur, or too rapid cooling of the outside, eventuating in cracks, as strains are set up in the already cooled portions by the cooling and consequent contraction of the remainder. Similarly, sudden changes of form, and particularly sudden changes in the thickness of the metal in a casting, are likely to result in breakage, the thinner portions cooling much more rapidly than those which are thicker. So far as is practicable, the same thickness of metal should be retained throughout, but if a change is necessary, it should be made gradually. All angles, particularly internal angles, should be rounded. In cooling, the metal is apt to arrange itself in lines parallel with the adjacent surfaces, so that sharp angles result in indefinite mitres in the metal itself, and these are sources of weakness.

Cast iron can be made into almost any conceivable form of which a pattern or mould can be made. It is most valuable in positions where continuous compression is to be resisted, but its resistance to tension is slight, as is also its resistance to shocks. It cannot be twisted, or worked under the hammer, or welded, or riveted. Pieces can only be joined together by the use of screws, collars or bolts. It is much used for common gates and railings, but is very liable to break, and it is rarely used where special designs are called for, when wrought iron would be cheaper and more durable. Regular painting is essential as a preservative. It cracks suddenly, with little or no warning, whether failure be due to shock, over-loading, or exposure to fire.

Wrought iron has been almost entirely replaced by mild steel for heavy structural work, but it is still much used for conversion into hard steel and for small forgings, and particularly for ornamental work, where a tough material, easily handled, bent, or welded is required. Chemically, even in respect to the quantity of contained carbon, it does not greatly differ from mild steel, and in fact, the two often overlap; but its method of manufacture is entirely different, and the resulting material has very different properties. White, mottled, or hard grey pig iron is loaded and melted upon the hearth of a reverberatory furnace. When molten, slags containing oxide of iron are introduced, with the result that the carbon in the pig iron combines with the oxygen they supply, bubbling or boiling off as CO, which ignites, and so assists to raise the temperature of the furnace, this being necessary as the melting temperature of the metal steadily rises as the proportion of contained carbon diminishes. Before long, however, this can go no further, the boiling ceases owing to the carbon having been nearly eliminated, and the metal collects in lumps in a sticky condition. These lumps are brought together with rakes, worked through a side door, and the ball thus made is withdrawn from the furnace, the whole process being known as "puddling". It is then compressed, either by blows from a steam hammer, or by means of a squeezer which acts like the upper arm of a pair of nut-crackers against a bed-plate. In this way the greater part of the contained slag is squeezed out, and the bloom thus formed is passed between rollers to further consolidate it, the result being known as "puddled" bar. This is cut into short lengths, which are "piled", or tied together with wire, reheated, again in a reverberatory furnace, and again hammered and rolled, when it is known as "merchant" bar. Repetition of the process produces "best" bar. If the puddling be stopped at a stage short of the complete elimination of the carbon, "puddled steel" is produced, but this is rarely done, owing to the difficulty of obtaining exact proportions.

The temperature in a reverberatory furnace being considerably less than in a Bessemer converter or a Siemens-Martin hearth, puddled, or wrought, iron is never perfectly fused, so that after being hammered and rolled it consists of a series of parallel fibres arranged to form laminae, somewhat like the flakes of pastry which are similarly produced by piling and rolling. Slag which has escaped being pressed out exists between these fibres and laminae, and the material is consequently not homogeneous. The higher qualities, however, have considerable tenacity, and a silky fibrous fracture of grey colour. Until very few years ago wrought iron thus manufactured was used for almost all purposes for which mild steel is now universally employed. Owing to much of the contained impurities existing as intermixed slag, and not intimately combined with the metal, a larger proportion, as detected by chemical analysis, can be carried without injury than is the case with mild steel. Wrought iron is obtainable in plates, rectangular bars or circular rods, and may be cut, twisted, and bent in any direction or hammered out flat, or into bulbous knobs; but it cannot be obtained in mass. Pieces can be joined together by welding, or by riveting, or by means of wrought-iron collars, but as a rule the joints form weak spots. Wrought iron shrinks as it cools, and advantage of this can often be taken to produce very tight connections, a collar being put on hot and allowed to cool on. Only such forms are obtainable, either for construction or ornament, as can be made by hammering, cutting, and planing. Complicated designs have to be built up of many small pieces, each separately formed. It resists shocks admirably, and so is most suitable for gates and railings; but it rusts readily, and should be kept well painted if used externally. It should not be used in contact with oak, the gallic acid in which attacks the metal, nor in contact with other metals, such as copper, with which a galvanic circuit would be completed in presence of moisture. It bends and twists if exposed to great heat, but bends before it breaks, and so gives warning at all times of impending failure.

Text 20. Mild steel

There is another important method of manufacturing hard steel, such as tool steel, known as the *cementation process*, but it is not intended to do more than refer to it here. We may, however, note that by its means steel is produced from wrought iron. Our attention will be confined to the Bessemer and the Siemens-Martin processes, which alone are employed for the production of the mild steel used in structural work. Both these processes can be worked as either acid or basic. As originally designed, the Bessemer converter was lined with ganister, a highly siliceous material, refractory at high temperatures and acid in character. This only allows of the use of pure haematite ores, as others contain phosphorus, and this can only be eliminated freely in the presence of a base capable of forming a stable phosphate with the oxidized phosphorus. As non-phosphoric ores are comparatively rare and costly, a basic lining is therefore more commonly used, consisting of dolomite, and to produce the best results with such a lining the ore should not only contain phosphorus, but this element should be present to a fairly rich extent. In the basic Bessemer process the crude iron is run direct from blast furnaces into ladles of large size, which are conveyed by small engines on trucks along railway metals to a mixer, or rocker, into which is poured the contents of several ladles from several different furnaces. The rocker is then set in motion, and the contents, when well mixed, are poured into another large ladle and conveyed to the converter. This is a large pear-shaped contrivance, hung to revolve vertically, with a hot blast introduced through "tuyere" holes at or near the bottom. It is first heated by a charge of burning coke, which is raked out, and then, if its lining be basic, a proportion of quicklime, of from 10 to 15%, by weight of the total charge, is introduced, and the molten iron is poured in. If the lining be acid, the quicklime is not needed. The blast is now introduced, and the converter is turned into a vertical position. The blast is continued for about 18 or 20 minutes, during which time important chemical changes take place, which can be followed by the colour and character of the flame and sparks emitted, resulting in the almost complete removal of impurities, including the carbon, when a stream of white-hot nitrogen from the air of the blast alone escapes. If the lining be basic this is continued for a short period known as the "after-blow", during which the phosphorus is oxidized and combines with the lime to form a basic slag, which is poured off. At this stage the blast is stopped for a moment, and spiegel-eisen, containing a known proportion of carbon and manganese, is introduced; or, if a metal very low in carbon is required (25%), ferro-manganese is substituted for the spiegel-eisen, as by this means a smaller proportion of carbon is introduced for a given amount of manganese. Blowing is now continued for a few minutes to effect perfect incorporation, and then finally stopped. This is swung round, and the contents of the ladle are poured into large iron moulds, which stand upright upon railway trucks. Before long the metal cools sufficiently to stand by itself, when the mould is removed, and the truck is taken away with a glowing "ingot" of red-hot steel standing upon it, possibly 6 ft. high and 18 ins. square.

Text 21. Copper

Native copper is found in large masses about Lake Superior, and in veins, distributed in crystalline form through granites and other rocks, in Cornwall. There are also many forms of copper ore, including the red oxide, known as cuprite; the black oxide and copper gravel; and the carbonates: malachite and azurite. The most abundant copper ores are the pyrites, though they are usually associated with gangue and arsenic and with an excess of sulphide of iron. The methods of reduction are numerous and complex, the three principal being the Dry Welsh Process, in which reverberatory furnaces of different forms are used for calcining and melting the ore alternately several times; the Wet Process, in which the copper is chemically dissolved from its sulphide ores; and the

Electrolytic Process. Of these the Welsh process alone need be described in detail. Several cargoes of ore are successively deposited in one large heap, and the heap is cut away in vertical slices so as to mix the ores. This mixture is first calcined and so reduced to a black powdery form, and then melted in a reverberatory furnace, so constructed that while a great heat is generated, beating down from the arched roof upon the dish of ore, the fuel and the ore do not mix, but the flame and smoke from the fuel pass over the ore to the chimney. As the ore melts, the metallic portion drops to the bottom of the dish, and a lighter scum of slag rises to the surface. This is skimmed off with an iron rabble through the door, and its place taken by fresh calcined ore, and the skimming and filling repeated till the dish is full of metal only, which is then run out through the tapping hole into water and so granulated. The whole process of calcining, melting, skimming and granulating has to be repeated three times before a product containing even so much as from 80 to 90%, of copper is obtained, and this is then cast into pigs instead of being granulated. The pigs are again melted, or roasted, under a strong current of air, and again cast into pigs, which are of honeycomb structure internally and covered outside with black blisters. This "blister copper" is refined by re-melting, or refining, under a gradually increasing temperature, and the final slag skimmed off. The surface is then covered with charcoal, and a pole, usually of birch, is held in the liquid matter, causing considerable ebullition; and this poling is continued, with the addition of fresh charcoal so as to keep the surface covered, until by the assays which are taken from time to time it is found that the grain, which at the commencement of the operation was open, has quite closed, so as to assume a silky, polished appearance in the assays when half cut through and broken. The malleability is then tested by taking out a small quantity in a ladle, pouring it into an iron mould, and when set, and still hot. If it stands this without cracking at the edges, the metal is sufficiently toughened, and may be ladled out in clay-lined ladles and poured into moulds. The reddish-brown sonorous metal thus produced is extremely soft and malleable and considerably ductile, with a specific gravity of about 878 and an ultimate tensile strength of about 7 tons per square inch. Castings are rarely made from pure copper, owing to its extreme softness, but this is corrected by alloying it with zinc or tin. When hammered and rolled, copper becomes rigid, stiff and hard, and even liable to crack and disintegrate, the change being purely mechanical. The specific gravity increases up to 90 and the tensile strength to 15 tons per square inch; while copper wire, Jth of an inch in diameter, may be worked up to such a condition that it will require a strain of 300 Ibs. to pull it asunder. On exposure to the atmosphere, a protective film of so-called verdigris, a basic carbonate of copper of a green colour, forms upon the surface, rendering the metal practically indestructible. On this account it is extensively used for masonry dowels; and, when the first cost is not prohibitive, for glazing bars. It is also used for lightning conductors, being an excellent conductor of electricity, and hot-water piping, geysers, baths and ventilators; but should be avoided in connection with drinking water, as the verdigris coating just mentioned is highly poisonous. Sheet copper is one of the best roofing materials known, being very light, absolutely impervious, and practically everlasting, capable of being laid flat, as in flats and gutters, or of being worked to any curve, and developing a beautiful colour. The thickness known as 24 B. W. G., weighing 16 ozs. per foot super, is almost invariably used, for though thinner metal would generally suffice, it is more costly to roll, and anything thicker would be extravagant. Hardened copper sheeting has of late been introduced by Messrs. Ewart & Son for rain-water eaves, gutters and ornamental features, such as finials, as being capable of standing with little or no support. Copper wire is used for electric lighting, electric bells, and for ordinary bell-hanging. This is not a true verdigris, which is a basic acetate of copper.

Text 22. Lead

Little lead ore is now found in England, though at one time lead mining was an extensive industry in the North of England, Derbyshire, Wales, and Scotland. Most of the metal now in use is obtained as a bye-product of silver mining, as at the Broken Hill Mines in Australia, while a good deal is also obtained in the United States, Spain, the Hartz district of Germany, and Peru. The ore is mechanically separated out from the gangue, or spar with which it is mingled, and then roasted and reduced in a cupola or blast furnace. The principal ore is galena (the sulphide); though cerussite (the carbonate) is extensively worked at Leadville, Colorado; and anglesite (lead sulphate) is occasionally found, especially in combination with silver. Crude lead thus obtained needs refining before it is ready for use, but the following analyses show that after refining it becomes almost absolutely pure: Lead is one of the heaviest substances known, having a specific gravity of 35. It has a low melting point (617 Fahr.), and is soft and easily bent and worked or beaten out to any desired form; but it is by no means ductile, and is greatly wanting in strength, being easily crushed, torn, and twisted. At the same time it well resists wear, and is practically impervious to water. This last quality, together with its pliability, renders it a most valuable material for use in water-carrying pipes, and for lining cisterns and sinks, while, used horizontally, it is one of the best roofing materials, as only just enough fall need be given to enable the water to flow towards the gutter or outlet and to compensate for accidental irregularities in the laying a fall of I in 120, or I in. in 10 ft., being usually considered sufficient. Where good work is required it is similarly used, almost universally, in gutters behind parapets and between roofs, in roof valleys, and as apron flashings. Its low melting point, combined with its impermeability, has caused lead to be largely used in a molten state for making joints in iron pipes, and for ”running in” iron cramps and the joints of iron railings to stonework; but not with success except under cover, as in the presence of moisture, and particularly in that of soft rain water, galvanic action is set up between the lead and iron, resulting in the destruction of both metals. The lead as received from abroad is melted in a large copper pan with a furnace beneath it, similar to the ordinary domestic copper, only larger in size, and supplied with a valve near the bottom for letting out the molten metal. From this valve it is conveyed to any spot desired in semi- circular troughs. The moulds, which contain I cwt. of metal each, and are semicircular in section, are arranged in fan form round the furnace, and the lead is poured into each in rotation, any scum due to the metal becoming chilled being carefully removed and returned to the furnace. Chilled lead, though pure, is brittle and of little value, so that its use must be avoided. Sheet lead is generally made by casting a plate of lead about 5 ins. thick, weighing about 7 tons, and then passing this under metal rollers until it is squeezed down to the required thickness. Such sheets are known as “milled lead”, and can be gauged very accurately, the various thicknesses being known by the weight in pounds per foot super. Such sheets are commonly made in lengths up to 35 ft., and in widths which vary from 5 ft. 6 ins. to 8 ft., but greater lengths and widths can be obtained if desired. Sheets can also be made by pouring the molten metal on to a carefully levelled bed of sand on a wooden bench, and then passing a “strike” over the surface to sweep away any surplus beyond the desired thickness. Such sheets are known as “cast lead”, and they are generally thickerthan the milled sheets and smaller in size. Many architects, however, prefer cast lead, holding that the natural structure of the metal is broken up in the passage through the rollers, and that milled lead is thus rendered brittle and liable to crack if exposed to changes of temperature, as is inevitable upon roofs. Gauges are procurable for testing the thickness of lead sheets according to the weight specified; but if any doubt exists it is best to cut off a rectangular piece from a sheet and weight it carefully, computing from that the weight of a square foot. In general practice, 4 or 5 Ibs. lead isspecified for aprons and flashings; from 6 to 8 Ibs. for roofs, flats, and gutters; and from 5 to 7 Ibs. for ridges and hips; but in exposed situations or on flats liable to wear these thicknesses are hardly sufficient. A very thin sheet is also rolled, known as “laminated lead”, which is used as a lining to damp walls underneath the paper.Lead pipes are made in a hydraulic press. There are two steel cylinders, of which the upper is fixed while the lower is gradually lifted by hydraulic pressure, the lower one exactly enclosing the upper. In the upper cylinder a steel die is fixed, having a circular opening, whose diameter is exactly equal to the desired outer diameter of the pipe; while a steel mandril is fixed in the lower cylinder, whose diameter is equal to that of the inside of the pipe. Molten lead is poured into the lower cylinder till it overflows, when the chilled scum is removed, and the metal allowed to partially cool. The hydraulic pressure is then applied to the lower cylinder, which rises, exactly encloses the upper cylinder, and forces the lead upwards between the mandril and the die. Large pipes that is, pipes of 2 ins. internal diameter and more are helped to rise vertically, and are generally cut off in lengths of 10 ft. Pipes from i to 2 ins. in diameter are rolled in coils of 36 ft. long, containing three “lengths” of 12 ft. each; while the coils of all smaller pipes than this contain four “lengths” of 15 ft. each, or a total of 60 ft. The weight in pounds per “length” is stamped at each end of each coil. All the smaller pipes should be made of perfectly pure, new and unchilled lead, that they may bend readily as desired without cracking; but large pipes, like soil pipes, require to have more stiffness, and this is imparted by mixing some old lead with the new.

Text 23. Zinc galvanized iron

The principal zinc ores are those known as the calamine, zinc-blende or black-jack, and the red oxide. The ore is reduced by roasting, mixing with half its weight of coke or non-caking coal, and then heating in retorts, the metal being driven out as a vapour, condensed, and then refined by melting on a hearth provided at one point with a well, into which any contained lead (from 1 to 3%) settles out in the course of 2 or 3 days. The metal thus produced is brittle and fusible; but it becomes malleable at about 220 Fahr., and at that temperature can be rolled into sheets which retain their malleability though at a higher temperature, about 400 Fahr., this malleability is again lost. Its melting point is 774 Fahr., and it has a specific gravity of 7. On exposure to the atmosphere a protective film of zinc oxide is soon formed on the surface; but unfortunately this has not the permanent protective effect that verdigris has upon copper, especially near the sea and in large towns, as sea salt and acids act harmfully and soon destroy the metal. Soot and urine are also destructive to it, and consequently zinc should not be used in positions accessible to cats. It is important that zinc should be pure when it is of uniform colour (dull grey), tough, and easily bent without cracking; while if impure, it is darker in tone and blotchy in appearance. If it contain iron to any perceptible extent it will not resist the action of the air, while the presence of lead makes it too brittle to roll. Sheet zinc is largely used for flat roofs, gutters, and flashings, and is supposed to have a life of about twenty years under ordinary London suburban conditions. It is also stamped into ornamental tiles, ridge cresting, and eaves gutters, and is even used for rain-water pipes; but its brittleness and want of stiffness prevent its being of much value if so employed. As a lining to drinking-water cisterns it is satisfactory, but its greatest value is as a protective coat to ironwork, and as a component of alloys. If zinc be allowed to come in contact with iron, copper, or lead in the presence of moisture, galvanic action is set up, and the zinc is rapidly destroyed. It catches fire at a low temperature, and blazes furiously. The expansion and contraction of zinc under changes of temperature are considerable, being more than those of other metals, not excepting lead, and must be carefully provided for by avoidance of rigid fastenings. Zinc is rolled in sheets of 6, 7 or 8 ft. long by 3 ft. wide; though longer sheets up to a maximum length of 10 ft. are obtainable by extra payment. The thicknesses are standardised by a special zinc gauge, by which they should always be specified. For roofing purposes, 14, 15, and 16 gauges are those mostly used, but 14-gauge zinc is really too thin to be reliable. Thinner gauges than this are mostly used in perforated sheets for ventilation purposes, and the thicker gauges are stamped into eaves gutters, ornamental tiles, etc. It is impossible to roll sheets exactly to any given weight or thickness, and therefore a slight deviation must be allowed.

GALVANIZED IRON. An important use of zinc is as a preservative coating to ironwork, known as *galvanizing*. The iron is first "pickled" in dilute acid to remove all rust and cleanse it thoroughly, and is then heated and immersed in molten zinc, which is covered with a layer of sal-ammoniac to keep it from evaporating. When withdrawn, a film of zinc is found to have adhered to the iron, which it preserves against rust so long as the film remains intact which it will do for some years if exposed only to rain and moderate wear, though it is soon penetrated in an acid or salt-burdened atmosphere, as also is sheet zinc. The articles most commonly galvanized are rain-water pipes, down pipes, manhole covers, and corrugated rolled sheets for roofing. These last are largely used, and should be corrugated before they are galvanized, else there is liability of the zinc being cracked during the process of corrugating. If this occurs, moisture entering the crack completes the galvanic connection between the two metals (iron and zinc), and both are then rapidly destroyed.

Text 24. Corrugated iron roofing

The Sheets should have 6-in. Laps, and be Double-rivetted at Joints: 3 Ibs of rivets required per Square. Hot galvanizing, as described above, is the process most extensively used to apply a zinc coating to iron and steel. Electro-zincing, or cold galvanizing, is used for special classes of work. A third method, called Sherardizing, has now been developed, and works have recently been completed for carrying it out on a commercial scale. By this new process iron and steel can be coated with a thin even deposit of zinc at a temperature below the melting point of this metal. The first step in the process is to free the iron from scale and oxide by any of the well-known methods, such as dipping in an acid solution or sand- blasting. The articles to be rendered rust-proof are then placed in a closed air-tight iron receptacle charged with zinc dust, which is heated to a temperature of from 500 Fahr. to 600 Fahr. for a few hours and allowed to cool. The drum is then opened and the iron articles are removed, when they are found to be coated with a fine homogeneous covering of zinc, the thickness depending on the temperature and the length of treatment The temperature required to bring about this result is about 200 below the melting point of zinc. The low temperature required makes the process cheap as compared with the process of dipping in molten zinc, and has the additional advantage that it does not deteriorate iron or steel of small section to the same extent as hot galvanizing. The whole of the zinc is consumed, and there is no waste of zinc as in the hot galvanizing process. This dry process of coating iron is not limited to zinc, but has been applied to coating iron with copper, aluminium, and antimony, and to coating other metals, such as aluminium and copper, with zinc. Copper and its alloys subjected to this process are case- hardened on the surface, and can be rendered so hard as to turn the edge of a steel tool. The zinc powder used is the zinc dust of commerce, and is obtained during the process of distilling zinc from its ores. One of its peculiar pro-perties is that it cannot be smelted or reduced to the metallic form under ordinary conditions even when heated to a very high temperature under considerable pressure, and this is advantageous in the new process of galvanizing, as it does away with the risk there might be otherwise of melting the finely divided zinc through overheating of the furnace.

Text 25. Alloys: brass and bronze pewter and composition

Intimate mixtures, or solid solutions, of metals, made by melting them together, are known as *alloys* possessing properties which differ widely from those of the metals of which they are composed, and varying in a strange and apparently erratic fashion, according to the proportions of the various mixtures. The most important alloys are those of which copper is the basis Brass, Bronze, Gunmetal, and a few others slightly differing from these to which special names have been given. They are much used for small cast objects, such as taps, door handles, hinges, and minor fastenings of all kinds, while those of harder character are employed for the bearings of machinery. All are prepared similarly. The metals of which they are composed are melted in crucibles or pots, generally made of plumbago, the less fusible metal being melted first, and those with lower melting points added afterwards in rotation. The crucibles are plunged into the heart of the furnace, each lasting for about three meltings, and the contents when incorporated are cast into ingots. These are remelted in the same way, a little old metal being commonly added to assist in perfect incorporation when casting is to take place. The objects to be made being small and in great demand, metal patterns are kept, with projections to represent the ends of the cores. The cores also are made in hinged metal moulds, of tightly packed loamy sand, slightly damp. As a rule several small objects are cast at once. The lower “flask” Pattern of Tap. nothing else than a metal tray, about 4 ins. deep is filled with sand with the pattern carefully inserted to half its depth. The pattern is withdrawn, the space it occupied dusted with dry sand, and it is replaced, when the dusting is repeated and carried over the whole surface of the lower flask. The upper flask, which has no top, is then dropped into place and packed with damp sand. When it is lifted it carries with it the sand it contains. The pattern can then be removed and the sand core placed in the sockets in the lower flask U which were made for it by The upper flask 7F5\ I i 1 1 is then quietly replaced in position and the metal poured into the space formerly occupied by the pattern through BLOWER FLASK carefully arranged holes, enment of Flasks. metal cools, the sand is removed from the flasks and the casting taken out, the sand core dropping out when tapped. All that is needed is for the rough surface to be smoothed and polished.

Brass, though the name is often given to all copper alloys promiscuously, properly means a mixture of copper and zinc, a little phosphorus being sometimes added to make it fusible. It is a tough alloy, its colour varying from a light to a reddish yellow, according to the proportions of its constituents, that containing more copper being the more red in tone; it is readily filed and cut; it casts easily, and can be easily burnished and kept brightly polished.

Bronze is the name given to alloys of copper and tin. These metals are difficult to combine, as their melting points and specific gravities are very different. Consequently Hard Metal is first made by putting the tin into twice its weight of copper, afterwards adding the rest of the copper, separately melted. Large castings are often not homogeneous owing to the difficulty of obtaining perfect incorporation. Under the names of Gun Metal and of Bell Metal, given to bronze containing certain proportions of copper and tin, it is largely used for machinery bearings, hinges, stop-cocks, and wherever resistance to constant wear is required in combination with a colouring similar to that of brass though richer in tone, and the capacity of retaining a good polish; and it is also much used, as its name implies, for bells. Several other copper alloys, mostly used for machinery bearings, but they are not much used in building work.

Pewter is the name given to any alloy of lead and tin. It is mostly used in building works for covering the counters of public-houses, but the softer and heavier qualities, containing more than 20%, of lead by weight, and having a specific gravity of more than 78, should not be used, as being liable to poison any liquid with which it may come in contact. Even then, however, it is not so dangerous as is sheet lead in a similar position. A slightly harder pewter, containing less than 17%, of lead, is occasionally used in ornamental panels. It can be either cast or stamped.

Composition, more generally known as compo., is made of lead, tin, and antimony. The harder qualities are used for slating nails, for which purpose compo. is well adapted, as it does not corrode readily, while it is cheaper than any alternative. Softer qualities are much used for inferior gas-piping, for which pure lead is unsuitable. Compo. pipes have the advantage that they can be easily bent and soldered like lead pipes, but their soft nature renders them dangerous for use unless properly cased especially when hidden beneath plaster as they are readily penetrated by a nail.

Block-tin pipe is also made, but is costly, and therefore not much used, but the same thing encased in lead is employed a good deal for the drawpipes for beer in public-houses and for the necessarily strong piping employed in mineral water manufactories.

Text 26. Paints: bases, vehicles, driers

Paint consists of at least two essential parts the Base, or general substance, giving consistency and covering power, and the Vehicle, or semi-liquid, in which the base isincorporated to enable it to be spread in a thin and even coat by means of a brush. In addition to these essentials, most paint includes some Drier which will combine with the vehicle in the presence of air and tend to harden and dry it rapidly; some Solvent, or freely-flowing liquid, used for diluting the vehicle until it is thin enough to be applied freely; and some colouring Pigment, introduced for decorative purposes. The characteristics of a good paint are that it should be liquid enough to be applied with a brush or spray; that it should dry within a reasonable time (48 hours); that it should adhere firmly to the surface to which it is applied; and that the dried surface should remain smooth, impervious, and moderately wear resisting.

BASES. By far the most commonly used Base, in England at any rate, is white-lead, though its employment is forbidden in France on account of its poisonous qualities. Other bases, more or less used, are red-lead, zinc-white, barytes, ferric-oxide, lithopone (rare), and a few of the pigments such as the ochres, umbers, and Prussian blue. Of these, *white-lead* is a basic carbonate of the metal, sometimes supplied as a powder, but more often mixed with from 7 to 9%, of linseed oil. Besides being used as a base for oil paint, it is frequently employed as a cement for the joints in iron pipes. Though several other methods of manufacture have been tried, the Dutch stack process is almost universally used. The purest metallic lead is cast into the form of cross-bar grids, which are laid over pans containing weak vinegar or acetic acid and covered with spent tan, this being again covered with boards. On top of the boards the arrangement of pan, grids and tan is repeated, and so on until a tall stack is built up. The chemical changes which take place do not seem to be very well understood, but apparently the acetic acid evaporates, converting the surface of the lead into basic acetate of lead. The tan heats, giving off CO 2, which combines with the acetate of lead to form a white basic carbonate of lead, that is, a carbonate of lead with excess of lead. In course of time the entire stack of lead is thus converted, and the grids are broken up and ground in water to a fine powder, and dried. To bring this into the best condition for use by the painter, the powder is mixed with refined linseed oil, and ground between horizontally revolving grindstones, until the pigment grain is entirely broken . The white-lead thus prepared is immediately packed in tins ready for use. It is insoluble in water, but dissolves readily in dilute nitric acid, and also, with effervescence, if heated in hydrochloric acid. Adulteration is therefore easily detected, by placing a little white-lead powder in a saucer and covering it with either of these acids, heating it over a gas flame if hydrochloric acid be used. Any insoluble residue will be an adulterant probably sulphate of barium. Pure English white-lead alone should be specified and used; while that of which the pigment grain has been thoroughly broken by grinding in oil possesses more covering power, when used as a paint, than that which is imperfectly ground. Unfortunately, white-lead is highly poisonous, both to those engaged in its manufacture and to painters who use it much. It also possesses the disadvantage of darkening considerably in impure air, and in the presence of sulphur in any form, and so cannot properly be used with some of the most beautiful pigments known, such as ultramarine for instance. It is also liable to change in composition. New dry white-lead has a different composition from that of the same sample after six, nine, or twelve months, and it changes still more when ground in oil.

Red-lead, or minium, is the higher oxide of lead, obtained by raising the lower oxide, generally known as Massicot, to a high temperature in air, during which process it absorbs oxygen and becomes further oxidized. It is sold as a bright red powder, the colour of which is permanent so long as it does not come into contact with any preparation containing lead or acids mixed with it; while in the presence of impure air it turns black. It is used more as a drier than as a base, being mixed with white-lead paints to make them dry rapidly; but is sometimes mixed with oil and then used as the base of paint upon ironwork, and for making watertight joints in ironwork and between wood and iron. At times it is mixed with white-lead when so employed. It is also the most frequently used base for the priming, or first coat upon woodwork.

Oxide of zinc, or “zinc white”, as it is commonly called, is much more largely used as a base than is generally supposed, for it is employed in almost all the paints to which special trade names are given. It is a simple zinc oxide obtained by distilling metallic zinc under a current of air. The zinc vaporises under heat, and picking up oxygen from the air, condenses on cool plates in the form of an amorphous white powder, of similar appearance to snow. This is rolled in water under pressure to increase its opacity and covering power, and is then ready for use after being dried and again ground in oil; and its value greatly depends upon the skill and thoroughness with which this is done. The principal advantages possessed by oxide of zinc are its pure white colour, which does not go off in the presence of sea air or of sulphur, the fact that it is non-poisonous, and its considerable covering power, though this last is only possessed by the better and dearer qualities, it being often thinned down with oil to reduce its price so as to compare favourably, apparently, with that of white-lead, with the result that the covering power is greatly reduced and much more has to be used. On the other hand, fewer coats of oxide of zinc paint than of white-lead paint are necessary, each being of first-rate qualit, so that when the initial additional cost of material in the one case is balanced against the extra cost of labour in the other, there is little or no eventual difference. Oxide of zinc is practically without action on linseed oil. Therefore the drying of paint made from oxide of zinc is due entirely to the siccative nature of the oil itself in which the oxide of zinc may be considered as mechanically suspended; a state of things more readily under control than is the case with white-lead paints, in which the powerfully siccative action of the hydrate portion of the white-lead often proceeds too far. The oil is then burnt up, so to speak, the paint perishes, and "chalking" results. The name of "zinc white" may also be correctly applied to another pigment Sulphide Zinc White which is the pigmentary base of much white paint now used.

Barutes (sulphate of barium) is more frequently used as an adulterant or reducer of white-lead or zinc white than as a base in itself, for it possessescomparatively little covering power.

Ferric-oxide (about 95%), produced from a brown haematite iron ore found in Devonshire, is sometimes used as a base for paint upon ironwork, especially for the first coat, there being a common belief that galvanic action is set up between lead or zinc paint and the metallic iron, which leads to its destruction. This is, of course, impossible so long as the skin of paint is intact, but may occur when it is broken and the galvanic couple completed by the presence of moisture. "Pure Magnetic" oxide of iron, containing 95%, sesqui-oxide of iron, prepared in chemically refined linseed oil, is a most valuable metal covering, but owing to the crystallization of oxide of iron, the first object of a good base is defeated, for it attacks the life of the oil. Oxide of iron does not combine with linseed oil at all, the process of drying depending alone on the absorption of oxygen by the oil, in which the pigment assists in a purely mechanical way. The higher the percentage of sesqui-oxide of iron contained in the oxide the slower the paint is in drying. Oxide of iron paints give very short protection to iron or steel in the presence of sea water.

Text 27. Paints: proportions for various coats

The proportions in which the ingredients of a paint are used vary largely, often according to the personal fancy only of an irresponsible and unscientific painter, but even in experienced hands according to climate, quality of materials, and many other considerations. It is now becoming more and more the custom to purchase paints ready mixed by reputable firms, and so long as these are not tampered with, and are used as directed, and under the conditions for which they are intended, it would be well-nigh impossible to improve upon the practice. The follouing table must be accepted accordingly as being approximate only for use on internal woodwork when all the materials are of good quality. Sometimes, for internal work, a last coat, known as “Flatting”, is added, which, made without oil and with turpentine only, dries with a uniformly matt surface, free from gloss. For external use, the most essential characteristic of a paint is durability, especially when it is applied as a protective coating to exposed structural steelwork. It is now usual to specify that the first coat at least upon steel shall consist of red-lead, and the wisdom of this is fully borne out by an exhaustive series of experiments. Fifty-one iron plates were coated, each with a different, carefully prepared paint, as nearly as possible under similar conditions. Each painted iron strip was placed in a clean wide-mouthed glass bottle half filled with clean pure water; the bottles were not closed, but were placed side by side on a shelf in the laboratory immediately under the table. The mouth of the bottles did not quite touch the under side of the table, so that, although there was free access of air to the painted plates, yet dust and other impurities were kept out. The bottles were allowed to remain untouched for three months. After about a week several of the plates had begun to corrode; this was shown first by a cloudiness in the water, which afterwards became further oxidized and formed a red precipitate of ferric oxide, or rust, which subsided partly to the bottom of the vessel. After the three months’ exposure the plates were removed, and the liquid in each bottle, together with the sediment, was carefully tested for the percentage of iron present in the form of rust; this figure was taken as denoting the amount of corrosion, but in every case was rather below the actual amount, as it did not include the portion which adhered to the iron plate. In each case the weight of rust found by experiment was calculated in Ibs. of rust per 1,500 square feet of painted surface, and this amount is set down in the second of the two columns of figures; the first column shows the percentage composition of the various paints employed. These results bring into prominence the want of durability of linseed oil alone, the improvement effected by mixing with it even a weak pigment, the high value of the red-lead and zinc-white bases, and the comparatively little deterioration resulting from even large adulteration of these with baryta. Cleanliness of metal before applying a protective coating is absolutely essential, and is a most important primary factor towards preservation: that is, absolute freedom from moisture, dirt, shop grease, flash scale and rust. Shop grease can be removed by repeated applications of benzine or lye water, afterwards washed with warm water and dried with cloths, or by the aid of heat. Rust and flash scale may be removed successfully by the sand blast, or with steel brushes and scrapers, and by “pickling” (treating with weak acid). Deep-seated rust spots should have heat applied to them, the usual method being the use of an ordinary painter’s torch; this converts the rust into a new body, peroxide of iron, which is easily removed by simply dusting off from the surface to be painted.

COLOURING PIGMENTS. Colouring pigments are obtained from such a variety of sources that their method of preparation also varies of necessity to a considerable extent. As a general rule, the various components, many of which are not divulged, are mixed by hand in water in large tanks, being stirred up with oars. When thorough mixture is secured, the pigment is allowed to settle and the water is drawn off. The sediment is then either pumped into a press which squeezes out most of the remaining water and converts the solids into cakes, or else it is drained of its water through cloths by hand, some of the more plastic pigments being incapable of treatment in presses. In either case, the semi-dry remainder is then put on racks in drying chambers, kept at different temperatures for various colours, some colours, notably ivory black, lake and flake white, being first pushed through a funnel and so formed into cones, known as "drops", and sold in this form when dry; though they can equally well, and more cheaply, be dried in rough lumps. Most colours, however, are ground to powder after drying, and are sold in powder form. Of late years, there has been a great tendency on the part of painters to buy their colours ready mixed, as mixing can be much better and more economically done by the manufacturer with good machinery than by the small user; and this is met by mixing the powder pigments to the required tints with the correct proportions of white-lead and linseed oil in pug-mills and then passing the mixture, for the finer tints at least, between cone-shaped granite grind-stones with oil and varnish, the colour thus produced being packed in air-tight tins. Some few colours, exceedingly useful for distemper, will not combine with oil, and so cannot be sold in a ready- mixed condition, but most are to be obtained in all three forms, in lump, in powder, or as mixed paint; and this is worth noting, especially with regard to those which are commonly supplied in the dry "drop" form, as it is erroneously and commonly imagined that they are not genuine in any other condition.

Text 28. Special paints

The composition of most of the special paints, now upon the market under well-known trade names, is secret, so that it is possible here to do little more than name the most prominent of them, drawing attention to some of their more obvious characteristics. They should all be used strictly in accordance with the directions supplied with them, without dilution or mixture of any kind. ”VELVRIL” is made with nitrated castor oil in place of linseed oil. This forms a thin and flexible skin which is absolutely impervious to water and non-corrosive. It is claimed for it that it resists acetic and mineral acids, diluted ammonia, and mineral and other oils; and that it is absolutely water-proof, oil-proof, rust-proof, and acid- proof, and resists all noxious gases. It can be made with metallic colours, such as aluminium, bronze, etc.; or in various colours, such as stone, red, green, slate, brown black, white, etc., or to any specification for a particular purpose. Its covering powers compare favourably with any ordinary oil paint, while its odour is not unpleasant, and disappears within two hours of its application. It is said to be antiseptic, and possess antiseptic properties; while it can be washed with antiseptic solutions, and consequently is specially suitable for hospitals, operating halls, etc. It is said that work which was done five years ago with this paint is still perfectly good, and the paint stands acid and sulphurous fumes in a very remarkable manner. Priming colours are specially prepared as a groundwork for the finishing coat, and should be used in all cases where two coats are required. The paint is easy to work and quick drying, giving a smooth, hard surface. Chancellor's "VELURE" and Gay's "IMPENETRABLE PAINT" are apparently similar to "Velvril", drying more slowly with a slight gloss, and somewhat "tacky" in use; but both are very durable and satisfactory, whether used on wood or metal, internally or externally. "RlPOLIN" is a varnish or enamel paint made with a gloss or flat finish, said to have all the qualities of the best varnish, combined with great covering, wearing and anti-corrosive properties. It is suitable for indoor or out-door work, resisting to a remarkable degree atmospheric influences, steam, heat, ammonia, and sulphurous vapours, is applicable for the highest decorative work, and at the same time, owing to its wearing properties, is economical for plain painting, having double the lifetime of the best white-lead paints. It is also suitable for painting surfaces exposed to the sea air and spray, being a perfect marine paint. Flat Ripolin is superior to the ordinary flatting, as it dries with a beautiful surface as smooth as silk, while it can be applied outdoors if necessary, and will wash as well as varnished work. In this respect it is unique, as ordinary flatting will not wear or wash properly, is easily soiled, and can only be applied on indoor work. Gloss Ripolin must be applied freely, and when so used will flow like a varnish. Whenever two coats of Ripolin are applied, the first coat should be a poor or thin coat, and then felted down like varnished work to receive the final full coat of Ripolin. Flat Ripolin usually requires two coats, and must be freely used and applied somewhat like flat varnish; although it is different in many respects, as it dries slowly, and about 48 hours must intervene before applying the final coat. Wall surfaces may be stippled. Flat Ripolin has good covering qualities, so the first coat can be substituted for one of the usual ground coats. The undercoating to Flat Ripolin should be made as for ordinary flatting, and if stained to finishing colour, one coat of Ripolin will frequently suffice. Aspinall's DECORATORS' enamel is apparently similar to Ripolin and is also supplied both matt and glossy. Several bath-enamels are upon the market, made by reputable firms, for the interior of baths and to withstand hot water; while the Indestructible Paint Co. supply Gold and Aluminium Enamels also. Blundell's black petrifying liquid, for the protection of steel and iron from rust, is said to be more lasting and effective than any other kind of paint, especially if applied over a coat of their black petrifying priming, which contains strong antirust properties. In appearance it compares with the best black Japan varnish, and stands heat, and is therefore suitable for boiler fronts, steam and hot-water pipes, stoves, grates, etc. It stands stoving, and will neither crack nor chip.

"Carbolizing coating" for use upon structural steel and iron work, is said to have a life of eight years and to be of great covering power, while the same makers produce a substance known as "Galvanum", which is the only paint made that will adhere properly to new galvanized iron, before the protecting value of the galvanizing coating has been sacrificed by exposure to weather. Both Carbonizing Coating and Galvanum form perfect bases for any finishing coat of any oil colour.

Text 29. Stone preservatives and damp wall solutions

Szerelmey's *stone liquid* is not a paint, and must not be treated as such. It isintended to be absorbed into the masonry, and not to lie on the surface. All porous work must have copious treatment. Sand stockbricks, and very open freestone require, in some cases, four coats to complete the treatment. When a glaze shows itself, it is an indication that the treatment is complete. The liquid thoroughly waterproofs the masonry, but does not alter its appearance, or have any chemical effect upon it. The best time for using it is in dry, hot weather; or in India and Australia in the hot season, before the rains commence. It should be rubbed in well with a stiff brush.

Browning's *damp wall soplution*, made by the Indestructible Paint Co., is similar in method of application and effect. It is claimed for it that:

1. The solution is colourless.

2. It leaves no deposit on the surface, and being invisible, it does not in any way alter the appearance of the coarsest stone or whitest marble. It need hardly be said that anything in the nature of a paint which should destroy or conceal the grain of stone is altogether inadmissible.

3. No vegetable or green appearance can be generated after its application.

4. Bricks, and the softest stone, and even chalk, are rendered by it thoroughly and lastingly weather-proof, not only against ordinary rain, but in the most exposed seaside situations.

Blundell's *petrifying liquids* are specially manufactured in different varieties, to comply with the following requirements:

1. A clear transparent solution, which is known as "Outside Flat-drying Transparent Petrifying Liquid", for the preservation of exterior stone, brick, etc., from decay. This has the property of penetrating any porous surface, whether stone, brick, or cement, to a considerable depth; it then slowly dries, filling up the pores, binding the particles together, and forming a really water-proof and durable surface, which is proof against the destructive effects of frost on a wet and porous surface. It also excludes and prevents any deleterious effects caused

by the atmosphere in towns, and being practically colourless and transparent, only very slightly affects the external appearance of the surface over which it has been applied, and has no tendency to darken or discolour with age.

2. A second object is to cure the interior surface of damp walls, so making them safe for subsequent painting, colouring, papering, etc. A somewhat different kind of Transparent Petrifying Liquid is generally used for this purpose.

3. The largest use for the Petrifying Liquids is for producing a white or coloured enamel-like appearance (either glossy or matt) over interior wall surfaces. In this way Petrifying Liquids may be looked upon as a much cheaper and yet satisfactory substitute for glazed-brick or tile; and they even have an advantage over the latter, inasmuch as there are no semi-porous cement or mortar joints to catch any dirt or infection. These liquids have great covering power, one gallon being sufficient to cover 40 square yards one coat. In all cases two coats are recommended.

Damp-resisting fluid is only adapted for inside walls; from which all old paper should be removed. New plaster on old walls, when hard enough to resist the pressure of the brush, may be painted or papered immediately the fluid is dry. It dries in about 6 hours, and becomes very hard.

FIRE-RESISTING PAINTS. Cvanite is a colourless preparation which can either be applied with a distemper brush, or into which light fabrics can be dipped, rendering them incapable of bursting into flame, and though they will still smoulder and slowly consume where actually exposed to fire, they greatly retard its spread.

Magnite has similar properties, but it is opaque. It can be used as the first coat for painting with ordinary colours.

Text 30.Varnish french polish and lacquers – enamel paints and japans stains

Gums, or the exudations of certain trees, mostly pines, in a soft or viscuous form, contain, as a rule, two substances, one an essential oil, and the other a resin. When the essential oil is evaporated, resin alone is left, and this, dissolved either in linseed oil, turpentine or alcohol (methylated spirit) forms *varnish*.

Varnishes may be divided under two headings, viz., *oil varnishes* and *spirit varnishes*, the former being composed of a compound of hard gum and linseed oil, thinned to the right consistency with turpentine, and the latter being prepared by dissolving another class of gum in spirits of wine (methylated spirit). The oil varnishes alone are suitable for exterior work, and are always much harder and more durable. Quick-drying spirit varnish is only suitable for indoor fancy work, and owing to itsbrittle nature, is easily bruised and injured. There are other, sometimes called spirit, varnishes which should be more strictly called turpentine varnishes, these being prepared from gums or rosin, soluble in turpentine without oil. The most expensive is mastic varnish, almost exclusively used for varnishing oil paintings. Whatever influence the solvent used may have on the quality of the resultant varnish, it is the uncharged resin alone which, after the evaporation of the solvent, constitutes the coat, and imparts to the varnish its distinguishing properties. Hard resin gives bright but brittle varnish; soft resin gives varnish which produces lustrous but more elastic coats, due to the essential oil contained in the resin, but the elasticity disappears as the essential oil disappears. Finally, by dissolving several resins together, the objectionable features of some can be done away with, whilst the properties of others are modified, thus securing a varnish adapted in every way for the object in view, which possibly could not be obtained by the use of any one single resin. What are generally known as Oil Varnishes are by far the most important class, and they may be divided into inside and outside oil varnishes, for the reason that there are many quick, hard, drying and comparatively cheap oil varnishes, that are suitable for interior work, but which are not sufficiently durable to long withstand the action of sun and rain and exposure to the weather.

There is a great art in properly running the gum in the pots by heat, and using the proper kind of oil in the right proportion, and this proportion depends upon the kind and class of hard gum used. Besides this, the varnish should be of the right consistency, neither too thin nor too round; this depends upon having the right proportion of turpentine. Lastly, there is the proper maturing of the varnish, which should be kept for a considerable time in iron tanks, in a house properly warmed with hot-water pipes: this so-called ageing and maturing of the varnish gives it time to deposit impurities and solid matter held in suspension ; it also acquires other properties with age, causing it to flow better off the brush, to produce a more even brilliant surface, and one not liable to bloom.

A man with some technical knowledge can test an inside oil varnish, by carefully spreading it over a given surface, noticing how it flows, the way and time in which it dries, and the appearance of the surface when dry. A varnish containing rosin, or even too much gum, very soon begins to get tacky. If there is too much rosin, the tackiness continues to the end, and though it appears to begin drying very well, it is a long time in properly hardening off. If there be too much gum it soon ceases to flow properly, and quickly gets tacky, but the tackiness quickly passes off, and the varnish dries off and hardens much too soon. This means a lack of durability, and great liability to bloom. No one can test the relative value and durability of an outside oak varnish, though by testing as above described, he can easily eliminate varnishes evidently not suitable for outside work. Those that pass this test can only be further proved by exposure to the weather, so that to arrive at the actual relative durability and merits of a selected number of makes of varnish must take something like 6 months, and even then a further 6 months' exposure will show unexpected defects in varnish which appeared to be perfectly satisfactory during the first period. The commonest article used for reducing the cost and making cheap varnishes is rosin, which should be avoided in the manufacture of all varnishes, whether for interior or exterior use. A very small addition completely ruins varnish for outside use. With regard to Spirit Varnishes, as shellac or sendarac do not perfectly dissolve in methylated spirit in the cold, it is necessary to effect the solution of these solids by the aid of a gentle heat. The aid of a sand or water bath is the usual means employed, so as to prevent the volatile spirit becoming too hot, which would cause loss by vaporization of the spirit and the production of a thick magna, too stiff to lay on with a brush. Such varnishes dry with a more brilliant gloss than those made by the cold process, but their adherence is not so great.

As the knowledge and capacity for making first-class varnishes means many years' experience and great skill and technical knowledge, the best thing to do is to deal only with old-established houses of repute. They know what they are doing, and will not send out a really unsuitable article if they can possibly help it. Most manufacturers list their varnishes under names which denote the purposes for which they are intended to be used and not their constituents, there being little agreement in the nomenclature.

FRENCH POLISH AND LACQUERS. A form of varnish which is largely used for hard woods, especially mahogany, being applied by rubbing it into the previously sand-papered surface of the wood, is known by the distinctive name of *French polish*. The simplest and possibly the best is made by dissolving 1 lbs. of shellac in I gallon of methylated spirit; but other gums are some- times used, and the polish may be darkened by adding benzine (with great caution owing to its inflammability), or may be coloured with dragon's blood. It dries in about twenty minutes, and gives a firm, hard and lustrous coat, which is durable and weather resisting, but brittle. The addition of a little gum elemi or gum copal renders it elastic. This also forms the basis of a large number of coloured varnishes sold under the name of walnut varnish, mahogany varnish, etc., all such colours being produced by the addition of suitable colouring matter to the spirit before or after dissolving the shellac therein.

An almost identical varnish is also known as *Lacquer*, different proportions of shellac and methylated spirit being used for different purposes. For application to hard wood generally to turned articles, by means of a rag while they are on the lathe 2 lbs. of shellac is dissolved in 1 gallon of spirit; while for brass, if the work does not require to l be coloured, a much thinner lacquer is used, J Ib. of the best pale shellac being dissolved with agitation in I gallon of spirit, and the mixture being allowed to stand and then filtered, it being constantly kept in the dark, as the effect of light is to darken its colour.

*ENAMEL PAINTS AND JAPANS***.** Though originally the term "enamel" was confined to vitreous enamels which were dried or baked by stoving, it has latterly been applied to a class of paints which dry with an enamel gloss, but otherwise differ from ordinary paints only in beingcompounded with a varnish (oleoresinous) vehicle instead of linseed oil and turpentine. The nature of the oleoresinous vehicle employed varies considerably. For hard enamel coats, copal and water resins are made use of, but inferior varnishes are also employed; though enamel paints compounded of a varnish vehicle in which rosin or rosin oil is an ingredient is of comparatively little value because rosin and its compounds never permanently dry or harden, and the result is a soft, sticky coat.

Spirit varnish enamels are usually made by dissolving ruby shellac or sandarac resin, or mixtures of the two, in methylated spirit for the production of dark enamels, bleached shellac being used for pale ones. Cheaper grades, made with benzine or naphtha as a solvent, are valueless, there being no binding qualities in these quickly evaporating liquids.

To enable enamel varnish to adhere to metal, it is usual to dissolve in the finished varnish, before grinding up the pigment therein, 5 to 1%, of boracic acid crystals; but not more than i per cent, should be used, otherwise it will have the opposite effect. The range of solid colouring matters that can be used is large, but there are some limitations. For instance, zinc oxides will form zinc resinates with the resin in the varnish and then decompose the compound; while red-lead also is a prohibited pigment, because it combines with the resinous ingredients to form a solid body.

Japanning, like enamelling, is properly performed with the aid of heat; but the word "Japan" is often used to signify a black enamel paint of the above character a confusion of terms which leads to much misapprehension.

Text 31. Enamelling and japanning gilding – whitewash colouring water paints

Vitreous enamels for metals are produced by fusing a base or flux on the metal. For high-class enamel work, not less than three coats should be applied, each coat being stoved and rubbed down before the application of the next one. The enamel is applied with a brush for good work, but for common work the article is dipped in a trough of the enamelling compound, when one or two coats only are applied. The difficulty in securing the attachment of the enamel to iron is found in the chemical changes which iron undergoes when heated. Iron is a metal that has very great affinity for oxygen; a drop of water allowed to dry on a piece of iron will leave a brown mark of iron rust. Again, when iron is subjected to a dry heat at a great temperature, oxygen from the air will also combine with the metal and produce on its surface a film of oxide of iron, which will be black or red in colour, according to the relative amount of oxygen that has combined with the metal. A fusive heat causes the greatest union, and produces a red oxide. Now, such a layer of oxide, even though it be but a mere film, will prevent the adhesion of the vitreous flux or base of which the enamel is composed. In the case of thin sheet iron, the mischief thus caused is more detrimental than in the case of thick iron vessels. To avoid this oxidation of iron it is usual to use a flux having a silicate of lead or a boro-silicate of soda base, which fuses at a lower temperature than that productive of iron rust. The surface of the metal is cleansed of all grease, oxide, etc., by scouring it; then the flux is spread over its surface in the state of powder, and the metal put into the stoving oven until the flux melts, when it is well spread over the surface of the iron and forms a vitreous coating.

The enamelling stove or oven has to be such that a temperature of at least 400 Fahr. can be attained. Transparent enamels are the base of all the coloured enamels, this transparent base being mixed with some suitable colouring matter. The base is produced by mixing its ingredients together by grinding them, then fusing the mixture and drying the fused base, which is again fused and again ground, when it is ready for use by being made into a paste with a little water. This paste is laid on the metal, and the metal put into the enamelling stove or oven to fuse and bake the enamel. The colours obtainable are most rich and varied, for although much indifferent enamelled metal work is to be seen, there is also much of extreme beauty.

Japans differ from enamel, inasmuch as they consist of a compound of resinous matter dissolved in spirits of wine (methylated spirit); and the art of applying these japans consists in drying off the coating of japan so that the vehicle is dissolved and the solid residue left as a firm, adherent glossy coating on the surface to which it has been applied. The preliminary operation in japanning consists in cleaning and drying the surface to be japanned. When of any other porous material, it is given, while warm, several coats of wood filler or whiting, mixed up with rather a thin glue size, and is, when this is hardened, rubbed down smooth with pumice-stone. It is then ready for the japan finish. As a rule, metals seldom require any spirit preparation, but receive the japan ground direct on the clean, dry surface. In japanning, wood and similar substances require a much lower degree of heat, and usually a longer exposure in the oven, than metals; and further, a higher temperature may be advantageously employed when the japan is dark than when light in colour.

The oven is usually a room or large box of sheet metal, and must be kept perfectly free from dust, smoke or moisture. The temperature is usually between 250 and 300 Fahr., at which it is found that the whole of the solvent or vehicle of the gum in the varnish is soon driven off, and the gummy residue becomes liquefied or semi-liquefied, in which state it adapts itself to all inequalities, and, if the coating is thick enough, presents a uniform glossy surface, which it retains in cooling. The coloured ground is put on first and dried in the oven. Then several coats of varnish are successively put on and dried, and the whole rubbed down to a smooth surface with fineFrench chalk, a little oil being finally used to clear off the powder and give the work a brighter hue.

Gilding, though it can be performed by using one or other of the various metallic paints upon the market, is more properly done by laying thin sheet gold upon a surface previously treated with japanners' gold size, and afterwards preferably treating it with several coats of varnish. Keep the oil hot and stir up well from the bottom while adding these ingredients. Then continue the boiling until the oil has been boiled about three hours and add 2 lbs. of gum anime, and continue the heating and stirring for 5 hours, or until the mass hangs in strings from the ladle, yet drops in lumps; then allow the mass to cool somewhat, and mix with it 3 gallons of turpentine, having raked out the fire so that the vapour given off does not catch alight. Well mix, when the gold size will be ready for use and should dry in 15 minutes or less, under favourable conditions. It improves on drying. The gold leaf used is classed as singles, doubles or trebles according to its thickness, and sold in books each containing 25 sheets, measuring 3j ins. square. It is obtainable in several different shades, varying from deep orange red down to a pale silvery hue what is known as "Pale Gold Leaf" being an alloy of silver and gold. Foreign gold leaf is thinner than the English, and the leaves are smaller. Dutch gold is copper leaf converted into brass and so coloured yellow by exposure to the fumes of molten zinc. It is cheap, and consequently is at times employed to cover large surfaces, but unless protected by varnish, it discolours.

Whitewash consists of pure white lime mixed with water, and is frequently used for common walls and ceilings, though it does not adhere well to smooth surfaces, and comes off when rubbed or exposed to rain; but it is cheap, cleanly and easily applied. The process of its application is generally known as lime-whiting. The wash is improved by adding 1 lb. of tallow (free from salt), to every bushel of lime. The following is a method of making an adhesive whitewash for external use:

Take a clean water-tight barrel, and put into it half a bushel of lime. Slake it by pouring water over it boiling hot, and in sufficient quantity to cover it 5 ins. deep, and stir it briskly till thoroughly slaked. When the slaking has been effected, dissolve it in water, and add 2 lbs. sulphate of zinc, and 1 lb. of common salt; these will cause the wash to harden, and prevent its cracking.

Common colouring is prepared by adding earthy pigments to the mixtures used for lime-whiting.

White distemper is a mixture of whiting and size. The best way to prepare it is to soak 6 lbs. of whiting in soft water for several hours, pour off the surplus water, stir the whiting into a smooth paste, strain and add a quart of size in the form of a stiff jelly. Mix carefully so as not to break the lumps of jelly, melt in a water jacket, strain through muslin, leave in a cool place for the whole to take the form of jelly, and dilute with water for use. The size should be used in the cold jelly form, else a rough surface will result. Potato starch may be used in place of size if a very clean bright white is required.

Coloured distemper is made by adding pigments to the whiting previously to introducing the size.

Water paints, made by many firms of repute under fancy names, have now largely replaced coloured distempers in general use. The best known of these are "Duresco", "Olsina", "Muraline", "Magnite", "Washable Distemper", "Calcitine", and "Stucco Paint". For most of these it is claimed that they are free from whiting, and from the sanitarily objectionable ingredient of size that they are readily applied, needing only to be mixed with water and that, once dry, they will withstand the application of soap and water to a moderate extent. They require, however, to be applied exactly according to the directions supplied by their makers, and when this is done, all are equally satisfactory. One of these, known as "Washite", is said to be fire-resisting and weather-proof.

Text 32. Glass

Glass is a brittle transparent or translucent compound formed by fusion at a high temperature of silica (silicic acid) with one or more basic substances, one of which must be an alkaline metal another well-known definition being that glass is a silicate of at least two metals of different groups, one of which must be an alkaline metal.

Thus, the essential substances are: 1) silica as the acid element; 2) soda or potash as the alkaline base; 3) lime and oxide of lead as alkaline earths.

Glass is not easily affected by water or ordinary solvents but is readily attacked by hydrofluoric acid, and slowly dissolves in hot water if the immersion is prolonged, and in damp air over a protracted period of time; thus accounting for the peculiar cloudy and obscured effect of much old glass, and for the beautiful effects of iridescent scaling. It is a bad conductor both of heat and electricity. While it will be noticed that the number of possible combinations is very great, for colourless glass it is essential that no iron impurities be present, either in the sand or lime.

Potash glass is free from the sea-green tinge present in the most brilliant soda glass, and the presence of red-lead is characteristic of flint-glass. Whatever the constituents, about one-third of the whole charge is always composed of waste and broken glass, known as "cullet".

Window glass may be either "crown", "sheet", or "plate", according to the method of manufacture, crown glass being made by rotation, varying in thickness in the same sheet, and showing circular markings; sheet glass being made in even thicknesses of known weight of so many ounces per square foot, the better qualities perfectly flat with few bubbles, and the lower qualities with a wavy surface distorting objects seen through it, and containing long, narrow bubbles; and plate glass being made by casting, in thicknesses known by fractions of an inch, perfectly flat, and with few globular bubbles.

Crown glass generally flint-glass is now little made, and need not be described in detail.

Sheet glass, while varying much in composition, may be considered to typically consist of: sand, chalk or limestone, sulphate of soda,cullet.These substances are mixed together, and put into large fireclay pots, containing from 20 to 22 cwts. each, which are ranged along the sides of furnaces, each pot opposite an opening, with platforms or stages radiating from the openings, and raised some 7 ft. above the bottom of a pit, that the blower, standing on the platform, may have a space below him in which to swing his blow-pipe. At the extremity of each platform farthest from the furnace is a water bucket and a moulding block. The contents of the pots take 16 hours to heat, and 8 hours more to cool to working consistency. When the right temperature is attained, a workman standing on each platform takes a blow-pipe, 6 ft. or 7 ft. long, dips its end into the pot opposite to him so as to gather on it a lump weighing about ij Ibs., and then cools this by swinging it in the pit ; redips and gathers more; and so on till he has a lump of hot glass weighing about 20 Ibs. on the end of his pipe. This he places in a horizontal position in his hollowed wooden moulding block and revolves while water is poured on; and then, when it is sufficiently formed and cooled, he blows down the blow-pipe, still revolving the glass in the block, until a hollowed globe is formed. This is re-heated and swung overhead, re-heated and swung again, until it is lengthened to a cylinder 45 irts. in length and 1 1 ins. to 16 ins. diameter, closed at one end, and with the blow-pipe at the other. The open end of the blow-pipe is now closed with the ringer, the further closed end of the cylinder being directed towards the fire, softening the glass and expanding the enclosed air, with the result that the softened end opens. It is now rotated rapidly while presented to the fire, and flashes out perfectly straight, as shown. The top, next the blow-pipe, is now cut off, and the cylinder (muff) which is thus formed is allowed to cool, and is then cut from end to end. This is put on the stone floor of a flattening oven with the split side upwards, and gradually heated, when it opens out by itself to a flat sheet, in which state it is inserted on edge in an annealing oven to cool down gradually.

Polished sheet or patent plate glass is made by polishing sheet glass in the way presently to be described, and is quite distinct from true plate glass.

Plate glass is made of the purest materials, and with the greatest care to avoid bubbles, the following being a typical mixture: white quartzose sand, soda carbonate, slaked lime, manganese peroxide, gullet. The melting pots are large, containing as much as 2 J tons of the mixture, which, when molten, is poured on to a table, and a roller passed over it to determine its thickness. The sheet of "rough plate" thus formed is taken to an annealing oven and gradually cooled, usually horizontally, and then examined for flaws, and cut to the largest size possible. It is then cemented with plaster of Paris on a table, which itself revolves horizontally under horizontal rubbers, being first ground with fine sand

and water; then smoothed with emery, starting with coarse and ending with fine grains; and finally polished with reciprocating rubbers having felt pads fed with rouge (peroxide of iron) the whole process being very similar to that already explained for polishing marble.

Rolled plate, either with plain grooves or with patterns raised or indented on the surface (known as Figured Rolled Glass), is made by the bed of the casting table being negatively enriched; and many exceedingly beautiful patterns of this glass, both clear white and coloured, are made, it being worth while, when selecting, to obtain samples from some well-known maker.

Figured rolled glass is made by rolling glass between two rollers instead of by a roller running on a table. The pattern is imprinted by a third (engraved) roller brought to bear upon the sheet of hot glass as it leaves the pair of rollers that determine its thickness. Many patterns are made, and the result is highly ornamental.

Obscured glass is generally obtained by subjecting ordinary clear glass to a sand blast.

Of *coloured glass* there are two kinds -Pot Metal, which is uniformly coloured throughout ; and Flashed Glass, which is ordinary transparent glass covered with a thin film of colour, by the blower dipping first into a pot of clear metal, then into one of colour, and so on. The colours used are metallic oxides, varying in proportion and in the temperature used, and in most instances are trade secrets.

Enamel glass (opaque) is made by including lead and tin oxides calcinedtogether, a typical mixture being: sand, pure potash, mixed oxides. This can obviously be made of many colours, and of it are formed the glass wall tiles, now largely used for lining such places as public conveniences, butchers' and fishmongers' shops, bath-rooms, etc. These vary from one another in little save the backing, which should preferablybe of some substance, such as a bituminous compound, which will allow the glass to expand and contract under changes of temperature, as otherwise unsightly cracks are sure to occur.

Wired glass is a thick glass with wire netting embedded in it, used in positions where shocks and blows are to be expected. It has proved to be highly fire resisting.

The "*maximum light glass*" is a combination of prisms and lenses used as a substitute for window, plate or stained glass, said to increase the light from 5 to 20 times. It consists of carefully arranged lenticular surfaces running in vertical direction on the outside and at right angles to prismatic projections on the inside, and is manufactured in various size sheets and angles to suit all existing condition maybe useful it being noted that first and second quality sheet glass is not used for building purposes, the highest quality in use being thirds, while fourths and fifths are commonly used.

Text 33. Wall and ceiling papers

The papers used for covering walls and ceilings are of several different descriptions, known by different names, which sometimes denote the character of the paper itself and sometimes the printing process employed. The commonest description of paper used is that known as Pulp Paper. It is thin, and is coloured throughout its substance, this colour being utilised as the ground of the design afterwards printed on it for it is very rarely used unprinted, except the white, and that only as a lining paper. Ingrain Papers also have the colour penetrating the substance. They are stout papers with a slightly rough and woolly surface, strong and serviceable, and exceedingly uniform in tint. As a rule they are used plain, as general wall coverings (or “fillings”, as these are technically called), but patterns, usually of a small and formal character in few tints, are occasionally printed on them. Their only objection is that the rough surface catches the dust, and they are consequently difficult to keep clean. Eltonbury Silk Fibres and Eltolines are again self-toned papers, smooth on one side and slightly roughened on the other, but not woolly, made of good substance and in beautifully pure tints. Like Ingrain Papers, they are somewhat expensive, but are strong and lasting; and though generally used plain are occasionally printed. Plain White Paper of good substance is, however, generally used, and is prepared for printing by coating one side of it with a coloured ground. This is done by passing it round a roller fed with colour from a trough by means of a blanket. Directly after leaving the roller, it passes beneath a series of reciprocating brushes which distribute the colour evenly over the surface, and it is then carried from the machine on to a rack, where it is suspended in festoons by rods over steam pipes to dry. At the " Essex " Mills, where the process was inspected, the paper from the racks is wound off on to a large roller at one end, dry and ready for printing, as it is fed from the machine at the other end. Grounds of two or more tints in parallel strips can be printed by using several colour rollers side by side, the reciprocating brushes doing the work of gradual mergence of the tints. Satin and Satinette Papers are made by brushing with powdered French chalk, or with a substance known as “satinette”, on a dried coloured ground; and Frosted Paper by more lightly brushing over with mica. Paper can be embossed by passing it between two steel rollers on each of which a pattern has been engraved, using considerable pressure; and this can be done either before or after printing.

Ordinary patterns with regular repeats are *machine printed*, all the variouscolours being applied at one operation. A separate wooden roller is used for each tint, so much of the pattern as isto be printed of that tint being formed upon the roller with copper lines and dots, or copper outlines filled with felt for the broader surfaces of this Paper “type” is exceedingly difficult work, as the rollers must all be set that the pattern may fit; and obviously the circumference of the roller, outside the raised copper work, must be equal to the length of a repeat. In the printing machine the paper is wound off a reel on to a large drum round which are set the various printing rollers, up to the capacity of the machine, at such distances that the patterns will exactly tally. As the drum revolves so do the rollers, each picking up colour from a moving inking blanket supplied from a trough. Thus colour after colour is printed, each being applied while the previous ones are still wet, rendering super-imposition of colours impossible if blurred effects are to be avoided; and the paper passes off the drum completely finished, and is carried at once to drying festoons.

All the best papers are, however, either *hand printed* or *stencilled*. For hand printing, the pattern is left raised upon a flat pearwood board by cutting down the portions which are not to print, copper strips and dots only being used for exceptional and slender work. The flat boards are backed with other wood, and the slab thus formed can be of any convenient size. There is a handle at the back for lifting it by, and it is alternately pressed upon a felt blanket stretched over a dish of colour, and upon the paper, which is slipped along a table, a "repeat" at a time, exact connection being made by means of marks along the edges. Very large patterns necessitate the use of 2 or 3 blocks to each repeat, they being applied in sequence. Only one colour can be printed at a time. If a hand-printed paper has more than one tint in it, the process has to be repeated for each additional tint, after drying, super-imposition of colours thus being possible. Gradual blending of tone can, however, be managed, by having two colours on the felt, gradually worked into one another.

Stencilled papers are made by cutting a stencil pattern in sheet zinc, the colour being worked in through the stencil with stiff, short-bristle brushes held nearly vertically in the fist, and worked with a rotary motion. Graded effects can be produced by this method which are not possible by any other. In all cases water-colours are used, but for machine printing these are necessarily thin and bound with gum, while for hand printing they are mixed with size and work as thick body-colour. Sanitary Wall Papers form a distinct and highly important class. They are of four classes, a specially prepared colour, water-proof and made with an oily medium, being used in each case, and the printing being done by machinery. One class is made by printing with this colour in the usual way with the usual rollers; but not much is made in this way. The best Sanitary Papers are printed from copper rollers on which the pattern is engraved instead of being raised, somewhat after the fashion of a mezzo-tint; and by means of lightly or more deeply engraving, many shades of colour can be obtained, only one roller being used. The pattern is thus printed on a surface already coated with the specially prepared colour, and the result is a smooth-surfaced paper which can be sponged. A third class of paper is made by calendering the paper instead of coating it with a coloured ground before printing, thus giving a smooth surface, which, however, will not stand washing unless great care be used; and the cheapest sanitary paper, printed from the roller direct on to unprepared paper, has not the same smooth surface, and can only by a stretch of courtesy be called either "sanitary" or "washable".

Flock and Cork Papers are made by printing the pattern in gum, and then beating flock or cork dust so that it adheres to the gummed surface, on which it appears as a rough raised surface. Such papers are distinctly handsome, but are rarely used as they catch dust with great readiness and cannot be kept clean. Japanese Papers are hand printed in Japan on very thick paper, in handsome patterns which are generally embossed, the colouring being brilliant and gilding being freely used. Lignomur is a thick embossed paper, almost a cardboard in substance, mostly used for ceilings, dadoes and friezes. It is made white only, but can be coloured or gilt in a variety of ways. Other very similar substances, some of them made in colour as well as white.

All English papers are made 21 ins. wide, within. margins, so that the actual width of the pattern is 20 ins. As a rule one margin is cut away for hanging, the other being overlapped; but in the best class of work both margins are carefully cut, and the edges are brought together. The paper is rolled in "pieces", each 12 yards long. As the paper machines are made for the standard width, this also determines the depth of machine-printed friezes, which may be loj ins. or 7 ins. gross the former technically known as a "two-over", and the latter as a "three-over" frieze, according to whether it is printed in 2 or 3 repeats on the width, and afterwards cut. Hand-printed friezes, however, are not subject to such strict limitations, and are obtainable of many other widths.

Fabricona is a name given to a fabric resembling coarse canvas made with a smooth back for use as a wall lining in several tints, and also with a surface similar to that of white duck. It makes a good background for pictures, and wears well.

Metal linings have also been introduced, and have at least the advantages of permanency and of requiring no underlying plaster. Of these, Emdeca is in thin enamelled sheets, slightly embossed, while Steleonite is of steel, much more richly embossed, and prepared for painting. Either can be screwed into position, while they are so thin that wire nails can be easily driven through them.

Text 34. Sundry materials of lesser importance

Asbestos occurs as a natural rock of a fibrous nature, found in South Africa and Austria. The fibres are separated, and woven into cloth or powdered. It is probably the most highly fire-resisting material known, becoming incandescent under direct flame without burning to any appreciable extent, but at the same time capable of resisting and refusing to conduct even considerable temperatures. Consequently it is the basis of almost all non-conducting cloths and packings used round steam and other hot pipes, between iron fireplace fronts and wood mantels, and in other similar positions.

Asbestos slates have been introduced of recent years, mainly for use in hot climates, they being fire and water proof, and unaffected by extreme variations of temperature. They are much lighter in weight than ordinary slate, and can be cut. sawn, nailed and screwed, veneered, ground, and painted. They are supplied both compressed and uncompressed, but to make the uncompressed slabs damp-proof they must be well coated with a thick boiled solution of soap. The following are the sizes made:

Uralite is similar to asbestos slates, made in sheets either plain or stamped with a pattern on the face, of asbestos fibre cemented by a mineral glue. It is intended to replace plaster upon ceilings and stud partitions, to which it can be screwed. It is made in thin slabs in two forms, hard and soft. The hard is used for roofs and other external work, ceilings, walls, partitions, doors, etc., and the soft for insulation, engineers' joints, and in the manufacture of fire-resisting doors.

Silicate-cotton, or *slag-wool*, possesses almost the same properties as asbestos, for which it is largely employed as a substitute, though it is also, and perhaps more, used as an exceedingly light sound-proof packing in which vermin will not live, and as the basis of various fire-resisting plasters. It is made by blowing a jet of steam through a small falling stream of molten slag, when it falls as a light open substance similar to cotton-wool, but more metallic in character.

Eubolith is a composition flooring, made partially of sawdust, which, like asphalt, can be laid without joint and is water-resisting. Whether it would wear evenly or last well would be matters for experience to decide. It is almost noiseless.

Lignolite flooring is laid like cement, sets quickly and becomes very hard, and is not cold to the touch like stone. It is fire- resisting and impervious, is easily repaired, and can be laid on either concrete or wood.

Ruberoid is a high grade felt roofing, containing no tar, pitch, rubber or other short-lived ingredient. It is made in four thicknesses, known as "plies", of which the J-ply is thin and recommended for underslating, while the 3-ply is very thick, for severe use and on roofs exposed to great heat and chemical action. It is also used for damp courses, and for flooring.

Laths are thin strips of wood or metal, about 1 in. wide and 3 or 4 ft. long, of various thicknesses, used as a support for plastering upon timber joists or studs. They ought to be split by hand from oak or fir heartwood, but the greater number now in use are sawn from fir sapwood by machinery. Plasterers' laths are classified as single laths, lath-and-half laths, double laths.

Expanded metal consists of mechanically-slit and opened-out sheets of metal, so as to produce trellis or net-like work, with diamond-shaped meshes and strands of, practically, any desired sizes and thicknesses. The cutting and opening out of the diagonal strands by the machine are effected in one operation. It is frequently used instead of lathing, as also are several other forms of cut metal sheets. It is manufactured in sheets of almost any convenient size, but the limit the long way of the mesh is at present 16ft.

Compo-board is a species of flat boarding built up in three thicknesses tightly glued together, of a thin layer of timber sandwiched between two even thinner slabs of card-board, the whole being no more than i in. thick. It is flat, strong, and rigid, and is an excellent and inexpensive substitute for lath and plaster either on walls or ceilings, being cheap and quickly put up, while it can be papered on immediately. It is made 4 ft. wide, and in all lengths at 1 ft. intervals up to 18 ft.

Venesta is a similar sandwich, but of three thicknesses of wood only.

Felt is a substance made from hair or wool beaten into a more or less compact tangle.

Asphalted Roofing Felt - a material manufactured for external roofing of sheds, barns, and other similar structures. When laid and covered with Coating Mastic a thorough and satisfactory job is secured, which will last, with very little attention, in good order for many years.

Sarking Felt – a material of similar nature to the above, but. of much lighter substance. It is only used for external work in the case of temporary buildings, such as lime sheds, etc., erected on the site of big buildings by the contractors for temporary storage. This felt is more largely applied as an underlining for slates, tiles, etc., but it is not inodorous.

Bitttminous Felt (Inodorous) – an underlining felt for any form of roof covering. This material, being inodorous, is very largely adopted for this purpose, and also but more especially in the case of isolation hospitals for lining walls, and sometimes under the flooring to render the building more secure against draughts, and also on account of the non-conducting properties of the felt.

Hair Bitumen - this material is by a long way the best underlining felt. It is largely composed of hair, and is used extensively as a sound-deadener in connection with partition work, and under flooring as a pugging. (In the latter position the material should be carried on the tops of the joists over the whole of the flooring, and not cut into strips and placed on the top of and (or) between the joists only; and this applies equally to all similar sound-deadening materials. For sound-deadening purposes the material is made a trifle stouter than when it is required as underlining for roof covering. It is vermin-proof.

Hair Felt is a loose, dry substance, not impregnated with any other. It is manufactured in sheets and in continuous lengths. The uses of hair felt are various, but it is mainly adopted as a non-conductor for covering boilers, tanks, pipes, etc., and also in buildings as the seating for girders.

Canvas-backed Hair Felt. Hair felt in strips in a handy form for covering hot and cold and steam pipes.Manufactured in two patterns, the "B" where the covering can be wrapped around the pipes, and the "A", with double margin, where the pipes are against a wall or other obstruction.

Stonifex Roofing Felt does not contain coal-tar or pitch, but is rubber-like and densely compressed. When exposed on a roof it oxidizes, and is extremely lasting, especially if coated with mastic, a precaution which should be taken with all felts used externally. It is of a dense black colour.

Willesden paper and *canvas* are often used in place of underfelting for roofs and for outside blinds and awnings. They are water-proof and rot-proof, made so by passing them through copper and ammonia (cuprium ammonium) in solution, the surface of the canvas being partially reduced to cellulose, and this again run back and pressed into the substance, thereby producing a semi-metallic surface highly impregnated with copper and ammonia. It is possible with this method of treating canvas to roll it up while still wet and put it away for an indefinite period without fear of mildew or rotting a most valuable quality, especially for sun-blinds. Both paper and canvas are made in several thicknesses and qualities for different purposes, and of various widths up to 60 ins., in rolls which vary from 90 yards to 360 yards in length.

Vulcanized rubber consists of indiarubber impregnated with sulphur. It is much used for valve seatings, and also as a packing to thick plate glass in place of putty. A rough way of testing its quality is to throw a piece into water. If it sinks it probably contains an injurious excess of sulphur.

Thatch is usually formed of thoroughly dry straw or reeds. The reeds used for thatching grow by the sides of large tracts of water, chiefly in the Eastern Counties. They are cut during the months of January and February after good sharp frosts. It is usual to wait for the "flag", which grows on top of the reeds, to fall before cutting. The lengths are various; 4 ft. to 6 ft. lengths are the best for ornamental or rustic work, and for circular and short rafter buildings, 4 ft. to 6 ft. lengths are most suitable. Some grow 6ft. to 9ft., but these are very coarse and only fit for long rafter work. In some districts a large proportion of rushes, boulders, or gladdin grow amongst reeds. They make very good, sound roofing, but do not look quite so well as all reed on a roof. All are tied up 18 ins. from stub end in bunches, or sheaves. The size or girth of tie varies according to custom of grower, or locality. Reeds are usually sold at per hundred fathom of 600 bunches, but sometimes 720 bunches are called one hundred fathom, and others sell at per hundred (60 bunches). Reeds should be laid in narrow rows to dry, or in small stacks, with a coat of thatch over, for the March and April winds to dry. They should be thoroughly well seasoned before being put on roofs, and over-year reeds are preferable, but very difficult to obtain. Wheat-straw thatch will last from 15 to 20 years, while reed thatch will last as long as sixty and even seventy years, if cleaned down and knocked up tight every 5 years.

Glue is made from animal offal of all sorts, such as hoofs, horns, and skin, by steeping it in water, and then washing, boiling, straining and melting it much as the stock for soup is made and casting it into square cakes. The best is of a clear dark amber colour, free from spots or cloudy patches, and swells much when immersed in cold water, without dissolving; while inferior glue will dissolve. The strength is increased by adding powdered chalk, but it is then rendered fit for coarse work only.

Size is made by melting glue with heat in water, and then adding more water until it is thin enough for use a pound of glue making about a gallon of size. Double size is merely size to which less water than usual has been added. Clear Cole is another name for size; while Parchment Size is made by dissolving fine chopped parchment in warm water for the use of gilders and is one of several varieties, all known as Gold Size.

Paste is generally made from white wheat flour, by mixing it into a stiff batter with a little cold water, adding cold water while stirring so as to thin the batter, and then pouring absolutely boiling water over it, stirring all the time, till it swells and thickens the process being exactly similar to that of making a cup of cocoa. The addition of alum just before the boiling water is added, makes the paste stronger, but more difficult to apply. Rosin and gum arabic are also sometimes added.

Rust cement, used for forming joints in cast iron work, is made from pounded cast iron turnings to which powdered sal-ammoniac and flour of sulphur are added, the mixture being first damped till it begins to heat, and then well mixed and covered with water.

Tar, which is a bye-product of the manufacture of gas, is obtained by heating coal in closed cylinders. From it are obtained, by distillation, in succession, coal naphtha, creosote and pitch.

Wood Tar, which is imported from the Baltic as Stockholm, and from the United States as American tar, is produced by distilling resinous wood; while Mineral Tar is found in Burmah or can be distilled from bituminous shales. A new substance has lately been introduced which forms a cheap and serviceable plastic material for fancy mouldings, cornices, pilasters, dados, skirtin. It consists of waste paper pulp a refuse from paper mills sawdust or inert material agglutinated by *algin*.

Algin is a jelly-like mass, of an alkaline nature and slightly adhesive. It is obtained from seaweed by the action of caustic soda.

PART III. TEXTS FOR HOME READING

Text 1. Artificial stone

Artificial stone is a name for various kinds of synthetic stone products used from the 18th century onward. They have been used in building construction, civil engineering work, and industrial uses such as grindstones.

One of the earliest was *Lithodipyra* (also called Coade stone), a ceramic created by Eleanor Coade (1733–1821), and produced from 1769 to 1833. Later, in 1844, Frederick Ransome created a Patent Siliceous Stone, which comprised sand and powdered flint in an alkaline solution. By heating it in an enclosed high temperature steam boiler the siliceous particles were bound together and could be moulded or worked into filtering slabs, vases, tombstones, decorative architectural work, emery wheels and grindstones.

This was followed by Victoria stone, which comprises finely-crushed Mountsorrel (Leicestershire) granite and Portland cement, carefully mixed by machinery in the proportions of three to one and cast in moulds of the required shape. When the blocks are set hard the moulds are loosened and the blocks placed in a solution of silicate of soda for about two weeks for the purpose of indurating and hardening them. Many manufacturers turn out a material that is practically non-porous and is able effectually to resist the corroding influence of sea air or the impure atmosphere of large towns.

Most later types of artificial stone have consisted of fine cement concrete placed to set in wooden or iron moulds. It could be made more cheaply and more uniform than natural stone, and was widely used. In engineering projects, it had the advantage that transporting the bulk materials and casting them near the place of use was cheaper than transporting very large pieces of stone.

Modern Cast stone is an architectural concrete building unit manufactured to simulate natural cut stone, used in unit masonry applications. Cast stone is a masonry product, used as an architectural feature, trim, ornament or facing for buildings or other structures. Cast stone can be made from white or grey cements, manufactured or natural sands, carefully selected crushed stone or well graded natural gravels and mineral coloring pigments to achieve the desired colour and appearance while maintaining durable physical properties which exceed most natural cut building stones. Cast stone is an excellent replacement for natural cut limestone, brownstone, sandstone, bluestone, granite, slate, coral rock, travertine and other natural building stones.Wood finishing refers to the process of refining or protecting a wooden surface, especially in the production of furniture.

Text 2. Basic wood finishing procedure

Wood finishing starts with sanding either by hand (typically using a sanding block or power sander), scraping, or planing. Imperfections or nail holes on the surface may be filled using wood putty or pores may be filled using wood filler. Often, the wood's color is changed by staining, bleaching, or any of a number of other techniques. Once the wood surface is prepared and stained, the finish is applied. It usually consists of several coats of wax, shellac, drying oil, lacquer, varnish, or paint, and each coat is typically followed by sanding. Finally, the surface may be polished or buffed using steel wool, pumice, rotten stone or other materials, depending on the shine desired. Often, a final coat of wax is applied over the finish to add a degree of protection. French polishing is a finishing method of applying many thin coats of shellac using a rubbing pad, yielding a very fine glossy finish. Ammonia fuming is a traditional process for darkening and enriching the color of white oak. Ammonia fumes react with the natural tannins in the wood and cause it to change colours. The resulting product is known as "fumed oak". There are three major types of finish: Evaporative, Reactive, Coalescing.

Wax is an evaporative finish because it is dissolved in turpentine or petroleum distillates to form a soft paste. After these distillates evaporate, a wax residue is left over. Reactive finishes use solvents such as white spirits and naphtha. Oil varnishes and linseed oil are reactive finishes, meaning they change chemically when they cure, unlike evaporative finishes. The solvent evaporates and a chemical reaction occurs causing the resins to undergo a change. This change prevents solvents from dissolving reactive finishes.Tung oil and linseed oil are reactive finishes that cure by reacting with oxygen, but do not form a film.Water based finishes generally fall into the coalescing category.

Clear finishes are intended to make wood look good and meet the demands to be placed on the finish. Choosing a clear finish for wood involves trade-offs between appearance, protection, durability, safety, requirements for cleaning, and ease of application. The following table compares the characteristics of different clear finishes. "Rubbing qualities" indicates the ease with which a finish can be manipulated to deliver the finish desired. Shellac should be considered in two different ways. It is used as a finish and as a way to manipulate the wood's ability to absorb other finishes by thinning it with denatured alcohol. The alcohol evaporates almost immediately to yield a finish that is completely safe but shellac will attach itself to virtually any surface, even glass, and virtually any other finish can be used over it.

Manufacturers who mass-produce products implement automated flatline finish systems. These systems consist of a series of processing stations that may include sanding, dust removal, staining, sealer and topcoat applications. As the name suggests, the primary part shapes are flat. Liquid wood finishes are applied via automated spray guns in an enclosed environment or spray cabin. The material then can enter an oven or be sanded again depending on the manufacturer's setup. The material can also be recycled through the line to apply another coat of finish or continue in a system that adds successive coats depending on the layout of the production line. The systems typically used one of two approaches to production.

In the hangline approach, wood items being finished are hung by carriers or hangers that are attached to a conveyor system that moves the items overhead or above the floor space. The conveyor itself can be ceiling mounted, wall mounted or supported by floor mounts. A simple overhead conveyor system can be designed to move wood products through several wood finishing processes in a continuous loop. The hangline approach to automated wood finishing also allows the option of moving items up to warmer air at the ceiling level to speed up drying process.

The towline approach to automating wood finishing uses mobile carts that are propelled by conveyors mounted in or on the floor. This approach is useful for moving large, awkward shaped wood products that are difficult or impossible to lift or hang overhead, such as four-legged wood furniture. The mobile carts used in the towline approach can be designed with top platens that rotate either manually or automatically. The rotating top platens allow the operator to have easy access to all sides of the wood item throughout the various wood finishing processes such as sanding, painting and sealing.

Staff is chiefly made of powdered gypsum or plaster of Paris, with a little cement, glycerin, and dextrin, mixed with water until it is about as thick as molasses, when staff is cast in molds it can form any shape. To strengthen it coarse cloth or bagging, or fibers of hemp or jute, are put into the molds before casting. It becomes hard enough in about a half hour to be removed and fastened on the building in construction. Staff may easily be bent, sawed, bored, or nailed. Its natural color is murky white, but it may be made to resemble any kind of stone.

Text 3. Wallpaper

Wallpaper is a kind of material used to cover and decorate the interior walls of homes, offices, and other buildings; it is one aspect of interior decoration. It is usually sold in rolls and is put onto a wall using wallpaper paste. Wallpapers can come plain as "lining paper" (so that it can be painted or used to help cover uneven surfaces and minor wall defects thus giving a better surface), textured, with a regular repeating pattern design, or, much less commonly today, with a single non-repeating large design carried over a set of sheets. Wallpaper printing techniques include surface printing, gravure printing, silk screen-printing, rotary printing, and digital printing. Wallpaper is made in long rolls, which are hung vertically on a wall. Patterned wallpapers are designed so that the pattern "repeats", and thus pieces cut from the same roll can be hung next to each other so as to continue the pattern without it being easy to see where the join between two pieces occurs. In the case of large complex patterns of images this is normally achieved by starting the second piece halfway into the length of the repeat, so that if the pattern going down the roll repeats after 24 inches the next piece sideways is cut from the roll to begin 12 inches down the pattern from the first. The number of times the pattern repeats horizontally across a roll does not matter for this purpose. A single pattern can be issued in several different colorways.

The main historical techniques are: hand-painting, woodblock printing, stencilling, and various types of machine-printing. The first three all date back to before 1700. Wallpaper, using the printmaking technique of woodcut, gained popularity in Renaissance Europe amongst the emerging gentry. The social elite continued to hang large tapestries on the walls of their homes, as they had in the Middle Ages. These tapestries added color to the room as well as providing an insulating layer between the stone walls and the room, thus retaining heat in the room. However, tapestries were extremely expensive and so only the very rich could afford them. Less well-off members of the elite, unable to buy tapestries due either to prices or wars preventing international trade, turned to wallpaper to brighten up their rooms.

Early wallpaper featured scenes similar to those depicted on tapestries, and large sheets of the paper were sometimes hung loose on the walls, in the style of tapestries, and sometimes pasted as today. Prints were very often pasted to walls, instead of being framed and hung, and the largest sizes of prints, which came in several sheets, were probably mainly intended to be pasted to walls. Some important artists made such pieces - notably Albrecht Dürer, who worked on both large picture prints and also ornament prints – intended for wall-hanging. The largest picture print was *The Triumphal Arch* commissioned by the Holy Roman Emperor Maximilian I and completed in 1515. This measured a colossal 3.57 by 2.95 metres, made up of 192 sheets, and was printed in a first edition of 700 copies, intended to be hung in palaces and, in particular, town halls, after hand-coloring. Very few samples of the earliest repeating pattern wallpapers survive, but there are a large number of old master prints, often in engraving of repeating or repeatable decorative patterns. These are called ornament prints and were intended as models for wallpaper makers, among other uses.

England and France were leaders in European wallpaper manufacturing. Among the earliest known samples is one found on a wall from England and is printed on the back of a London proclamation of 1509. It became very popular in England following Henry VIII's excommunication from the Catholic Church - English aristocrats had always imported tapestries from Flanders and Arras, but Henry VIII's split with the Catholic Church had resulted in a fall in trade with Europe. Without any tapestry manufacturers in England, English gentry and aristocracy alike turned to wallpaper. During the Protectorate under Oliver Cromwell, the manufacture of wallpaper, seen as a frivolous item by the Puritan government, was halted. Following the Restoration of Charles II, wealthy people across England began demanding wallpaper again – Cromwell's regime had imposed a boring culture on people, and following his death, wealthy people began purchasing comfortable domestic items which had been banned under the Puritan state.

In 1712, during the reign of Queen Anne, a wallpaper tax was introduced which was not abolished until 1836. By the mid-eighteenth century, Britain was the leading wallpaper manufacturer in Europe, exporting vast quantities to Europe in addition to selling on the middle-class British market. However this trade was seriously disrupted in 1755 by the Seven Years War and later the Napoleonic Wars, and by a heavy level of duty on imports to France. In 1748 the British Ambassador to Paris decorated his salon with blue flock wallpaper, which then became very fashionable there. In the 1760s the French manufacturer Jean-Baptiste Réveillon hired designers working in silk and tapestry to produce some of the most subtle and luxurious wallpaper ever made. His sky blue wallpaper with fleurs-de-lys was used in 1783 on the first balloons by the Montgolfier brothers. The landscape painter Jean-Baptiste Pillement discovered in 1763 a method to use fast colours.

Hand-blocked wallpapers like these use hand-carved blocks and by the 18th century designs include panoramic views of antique architecture, exotic landscapes and pastoral subjects, as well as repeating patterns of stylized flowers, people and animals. In 1785 Christophe-Philippe Oberkampf had invented the first machine for printing coloured tints on sheets of wallpaper. In 1799 Louis-Nicolas Robert patented a machine to produce continuous lengths of paper, the forerunner of the Fourdrinier machine. This ability to produce continuous lengths of wallpaper now offered the prospect of novel designs and nice tints being widely displayed in drawing rooms across Europe. Wallpaper manufacturers active in England in the 18th century included John Baptist Jackson and John Sherringham. Among the firms established in 18th century America: J. F. Bumstead & Co. (Boston), William Poyntell (Philadelphia), John Rugar (New York). High-quality wallpaper made in China became available from the later part of the 17th century; this was entirely handpainted and very expensive. It can still be seen in rooms in palaces and grand houses including Nymphenburg Palace, Lazienki Palace, Chatsworth House, Temple Newsam, Lissan House, and Erddig. It was made up to 1.2 metres wide. English, French and German manufacturers imitated it, usually beginning with a printed outline which was coloured in by hand, a technique sometimes also used in later Chinese papers.

19th century. France and America. Towards the end of the 18th century the fashion for scenic wallpaper revived in both England and France, leading to some enormous panoramas, like the 1804 20 strip wide panorama, *Sauvages de la Mer du Pacifique* (Savages of the Pacific), designed by the artist Jean-Gabriel Charvet for the French manufacturer Joseph Dufour et Cie showing the Voyages of Captain Cook. This famous so called "papier peint" wallpaper is still in situ in Ham House, Peabody Massachusetts. It was the largest panoramic wallpaper of its time, and marked the burgeoning of a French industry in panoramic wallpapers. Dufour realized almost immediate success from the sale of these papers and enjoyed a lively trade with America. The Neoclassical style currently in favour worked well in houses of the Federal period with Charvet's elegant designs. Like most 18th century wallpapers, the panorama was designed to be hung above a dado. Beside Joseph Dufour et Cie (1797 – 1830) other French manufacturers of panoramic scenic and trompe wallpapers, Zuber et Cie (1797–present) and Arthur et Robert exported their product across Europe and North America. Zuber et Cie's c. 1834 design *Views of North America* hangs in the Diplomatic Reception Room of the White House. While Joseph Dufour et Cie was shut down in the 1830s, Zuber et Cie still exists and with Cole & Son of England is one the last Western producers of woodblock printed wallpapers. For its production Zuber uses woodblocks out of an archive of more than 100,000 cut in the 19th century which are classified as a "Historical Monument". It offers panoramic sceneries such as "Vue de l'Amérique Nord", "Eldorado Hindoustan" or "Isola Bella" and also wallpapers, friezes and ceilings as well as hand-printed furnishing fabrics. Among the firms begun in France in the 19th century: Desfossé & Karth. In the United States: John Bellrose, Blanchard & Curry, Howell Brothers, Longstreth & Sons, Isaac Pugh in Philadelphia; Bigelow, Hayden & Co. in Massachusetts; Christy & Constant, A. Harwood, R. Prince in New York.

England. During the Napoleonic Wars, trade between Europe and Britain evaporated, resulting in the gradual decline of the wallpaper industry in Britain. However, the end of the war saw a massive demand in Europe for British goods which had been inaccessible during the wars, including cheap, colourful wallpaper. The development of steam-powered printing presses in Britain in 1813 allowed manufacturers to mass-produce wallpaper, reducing its price and so making it affordable to working-class people. Wallpaper enjoyed a huge boom in popularity in the nineteenth century, seen as a cheap and very effective way of brightening up cramped and dark rooms in working-class areas. It became almost the norm in most areas of middle-class homes, but remained relatively little used in public buildings and offices, with patterns generally being avoided in such locations. In the latter half of the century Lincrusta and Anaglypta, not strictly wallpapers, became popular competitors, especially below a dado rail. They could be painted and washed, and were a good deal tougher, though also more expensive. Wallpaper manufacturing firms established in England in the 19th century included Jeffrey & Co.; Shand Kydd Ltd.; Lightbown, Aspinall & Co.; John Line & Sons; Potter & Co.; Arthur Sanderson & Sons; Townshend & Parker. Designers included Owen Jones, William Morris, and Charles Voysey. In particular, many 19th century designs by Morris and Co and other Arts and Crafts designers remain in production.

By the early twentieth century, wallpaper had established itself as one of the most popular household items across the Western world. Manufacturers in the USA included Sears; designers included Andy Warhol. Wallpaper has gone in and out of fashion since about 1930, but the overall trend has been for wallpaper-type patterned wallcoverings to lose ground to plain painted walls.

Historical collections. Historical examples of wallpaper are preserved by cultural institutions such as the Deutsches Tapetenmuseum (Kassel) in Germany; the Musée des Arts Décoratifs (Paris) and Musée du Papier Peint (Rixheim) in France; the Victoria & Albert in the UK; the Smithsonian's Cooper-Hewitt, Historic New England, Metropolitan Museum of Art, U.S. National Park Service, and Winterthur in the USA.

Types and sizes. In terms of methods of creation, wallpaper types include painted wallpaper, hand-printed woodblock wallpaper, hand-printed stencil wallpaper, machine-printed wallpaper, and flock wallpaper. Modern wallcoverings are diverse, and what is described as wallpaper may no longer actually be made from paper. Two of the most common factory trimmed sizes of wallpaper are referred to as “American” and "European" rolled goods. American rolled goods are 27 inches by 27 feet in length. European rolled goods are 21.5 inches wide by 33 feet in length. Approx. 60 square feet. Most wallpaper borders are sold by linear foot and with a wide range of widths therefore square footage is not applicable. Although some may require trimming. The most common wall covering for residential use and generally the most economical is prepasted vinyl coated paper, commonly called "strippable" which can be misleading. Cloth backed vinyl is fairly common and durable. Lighter vinyls are easier to handle and hang. Paper backed vinyls are generally more expensive, significantly more difficult to hang, and can be found in wider untrimmed widths. Foil wallpaper generally has paper backing and can (exceptionally) be up to 36 inches wide, and be very difficult to handle and hang. Textile wallpapers include silks, linens, grass cloths, strings, rattan, and actual impressed leaves. There are acoustical wall carpets to reduce sound. Customized wallcoverings are available at high prices and most often have minimum roll orders. Solid vinyl with a cloth backing is the most common commercial wallcovering and comes from the factory as untrimmed at 54 inches approximately, to be overlapped and double cut by the installer. This same type can be pre-trimmed at the factory to 27 inches approximately. Furthermore, wallpaper comes in the form of borders, typically mounted horizontally, and commonly near ceiling level of homes. Borders come in varying widths and patterns.

Modern developments. Custom wallpaper printing. New digital inkjet printing technologies using ultraviolet cured inks are being used for custom wallpaper production. Very small runs can be made, even a single wall. Photographs or digital art are output onto blank wallpaper material. Typical installations are corporate lobbies, restaurants, athletic facilities, and home interiors. This gives a designer the ability to give a space the exact look and feel desired. High-tech wallpaper. New types of wallpaper under development or entering the market in the early 21st century include wallpaper that blocks certain mobile phone and WiFi signals, in the interest of privacy. The wallpaper is coated with a silver ink which forms crystals that block outgoing signals. The Spanish firm Think Big Factory has announced that they are developing a wallpaper which also serves as a computer interface, using projectors, webcams, and motion sensors for control. As of 2013, The hardware was complete but only 20 per cent of the software was finished, according to Think Big Factory. Seismic wallpaper. In 2012, Scientists at the Institute of Solid Construction and Construction Material Technology at the Karlsruhe Institute of Technology announced that they had developed a wallpaper that can help keep a masonry wall from failing in an earthquake. The wallpaper uses glass fibre reinforcement in several directions and a special adhesive which forms a strong bond with the masonry when dry.

Installation. Like paint, wallpaper requires proper surface preparation before application. Additionally wallpaper is not suitable for all areas. For example, bathroom wallpaper may deteriorate rapidly due to excessive steam. Proper preparation includes the repair of any defects in the drywall or plaster and the removal of loose material or old adhesives. For a better finish with thinner papers and poorer quality walls the wall can be cross-lined (horizontally) with lining paper first .Accurate room measurements (length, width, and height) along with number of window and door openings is essential for ordering wallpaper. Large drops, or repeats, in a pattern can be cut and hung more economically by working from alternating rolls of paper. Besides conventional installation on interior walls and ceilings, wallpapers have been deployed as decorative covering for hatboxes, bandboxes, books, shelves, and window-shades. Most wallpaper adhesive are starch or methylcellulose based.

Removal. The simplest removal option is to brush the paper with water. Water soaks through the paper and saturates the glue, allowing the paper to be peeled off.This does not work well with non-peelable vinyls, as vinyl is not porous. Nevertheless it is still effective on many modern papers. A mixture of 3:1 or 1:1 water and white vinegar is effective at dissolving glues. If the wallpaper is scored or sanded with a 20 grit floor sanding pad to scratch the surface solution uptake will be more effective. Chemical wallpaper stripper can be purchased at most paint or home improvement stores. It is mixed with warm water or a mixture of warm water and vinegar, then sprayed onto wall surfaces. Several applications may be required to saturate the existing wallpaper. Perforation can aid in the absorption of the mixture and lead to faster removal. After the mixture has dissolved the wallpaper paste, the wallpaper can be removed easily by pulling at the edges and with the aid of a putty or drywall knife. Another method of removal is to apply steam to wallpaper in order to dissolve the wallpaper paste. A wallpaper steamer consists of a reservoir of water, an electric heating element, and a hose to direct the steam at the wallpaper. The steam dissolves the wallpaper paste, allowing the wallpaper to be peeled off. However, care must be taken to prevent damage to the drywall underneath. Sometimes steaming can lead to the crumbling of underlying drywall or plaster, leaving an uneven surface to be repaired.

Text 4. Floor covering

Floor covering is a term to describe any finish material applied over a floor structure to provide a walking surface. Flooring is the general term for a permanent covering of a floor, or for the work of installing such a floor covering. Both terms are used interchangeably but floor covering refers more to loose-laid materials. Materials almost always classified as floor covering include carpet, area rugs, and resilient flooring such as linoleum or vinyl flooring. Materials commonly called flooring include wood flooring, laminated wood, ceramic tile, stone, terrazzo, and various seamless chemical floor coatings. The choice of material for floor covering is affected by factors such as cost, endurance, noise insulation, comfort and cleaning effort. Some types of flooring must not be installed below grade (lower than ground level), and laminate or hardwood should be avoided where there may be moisture or condensation. The subfloor may be finished in a way that makes it usable without any extra work: Earthen floor adobe or clay floors, Solid ground floor cement screed or granolithic.

There are a number of special features that may be used to ornament a floor or perform a useful service. Examples include floor medallions which provide a decorative centerpiece of a floor design, or gratings used to drain water or to rub dirt off shoes.

Subfloor construction. Floors may be built on beams or joists or use structures like prefabricated hollow core slabs. The subfloor builds on those and attaches by various means particular to the support structure but the support and subfloor together always provides the strength of a floor one can sense underfoot. Nowadays, subfloors are generally made from at least two layers of moisture resistant plywood or composite sheeting, jointly also termed *Underlayments* on floor joists of 2x8, 2x10, or 2x12's spaced generally on 16-

inch centers, in the United States and Canada. Some flooring components used solely on concrete slabs consist of a dimpled rubberized or plastic layer much like bubble wrap that provide little tiny pillars for the one-half-inch sheet material above. These are manufactured in 2 ft × 2 ft squares and the edges fit together like a mortise and tenon joint. Like a floor on joists not on concrete, a second sheeting underlayment layer is added with staggered joints to disperse forces that would open a joint under the stress of live loads like a person walking. Three layers are common only in high end highest quality construction. The two layers in high quality construction will both be thick $^3/_4$ inch sheets, but the two layers may achieve a combined thickness of only half-that in cheaper construction – $^1/_2$ in panel overlaid by $^1/_4$ in plywood subflooring. At the highest end, or in select rooms of the building there might well be three sheeting layers, and such stiff subflooring is necessary to prevent the cracking of large floor tiles of 9-10 inches or more on a side, and the structure under such a floor will frequently also have extra "bracing" and "blocking" joist-to-joist intended spread the weight to have as little sagging on any joist as possible when there is a live load on the floor above.

In Europe and North America only a few rare floors will be seen to have no separate floor covering on top, and those are normally because of a temporary condition pending sales or occupancy; in semi-custom new construction and some rental markets, such floors are provided for the new home buyer (renter) to select their own preferred floor coverings usually a wall to wall carpet, or one piece vinyl floor covering. Wood clad ("Hardwood") and tile covered finished floors generally will require a stiffer higher quality subfloor, especially for the later class. Since the wall base and flooring interact forming a joint, such later added semi-custom floors will generally not be hardwood for that joint construction would be in the wrong order unless the wall base trim was also delayed pending the choosing. The subfloor may also provide underfloor heating and if floor radiant heating is not used, will certainly suffer puncture openings to be put through for forced air ducts for both heating and air conditioning, or pipe holes for *forced hot water* or *steam heating* transport piping conveying the heat from furnace to the to local room's heat exchangers (radiators).

Some sub-floors are inset below the top surface level of surrounding flooring's joists and such subfloors and a normal height joist are joined to make a plywood box both molding and containing at least two inches of concrete. Alternatively, only a slightly inset floor topped by a fibrous mesh and concrete building composite floor cladding is used for smaller high quality tile floors - these "concrete" subfloors have a good thermal match with ceramic tiles and so are popular with builders constructing kitchen, laundry and especially both common and high end bathrooms and any other room where large expanses of well supported ceramic tile will be used as a finished floor. Floors using small ceramic tiles generally use only an additional $^1/_4$ inch layer of plywood and substitute adhesive and substrate materials making do with both a flexible joints and semi-flexible mounting compounds and so are designed to withstand the greater flexing which large tiles cannot tolerate without breaking.

Ground floor construction. A ground-level floor can be an earthen floor made of soil, or be solid ground floors made of concrete slab. Ground level slab floors are uncommon in northern latitudes where freezing provides significant structural problems, except in heated interior spaces such as basements or for outdoor unheated structures such as a gazebo or shed where unitary temperatures are not creating pockets of troublesome meltwaters. Ground-level slab floors are prepared for pouring by grading the site, which usually also involves removing topsoil and other organic materials well away from the slab site. Once the site has reached a suitable firm inorganic base material that is graded further so that it is flat and level, and then topped by spreading a layer-cake of force dispersing sand and gravel. Deeper channels may be dug, especially the slab ends and across the slab width at regular intervals in which a continuous run of rebar is bent and wired to sit at two heights within forming a sub-slab "concrete girder". Above the targeted bottom height (coplanar with the compacted sand and gravel topping) a separate grid of rebar or welded wire mesh is usually added to reinforce the concrete, and will be tied to the under slab "girder" rebar at intervals. The under slab cast girders are used especially if it the slab be used structurally, i.e. to support part of the building.

Floors in woodframe homes are usually constructed with joists centered no more than 16 inches apart, according to most building codes. Heavy floors, such as those made of stone, require more closely spaced joists. If the span between load-bearing walls is too long for joists to safely support, then a heavy crossbeam (thick or laminated wood, or a metal I-beam or H-beam) may be used. A "subfloor" of plywood or waferboard is then laid over the joists.

Utilities. In modern buildings, there are numerous services provided via ducts or wires underneath the floor or above the ceiling. The floor of one level typically also holds the ceiling of the level below. In floors supported by joists, utilities are run through the floor by drilling small holes through the joists to serve as conduits. Where the floor is over the basement or crawlspace, utilities may instead be run under the joists, making the installation less expensive. Also, ducts for air conditioning (central heating and cooling) are large and cannot cross through joists or beams; thus, ducts are typically at or near the plenum, or come directly from underneath (or from an attic). Pipes for plumbing, sewerage, underfloor heating, and other utilities may be laid directly in slab floors, typically via cellular floor raceways. However, later maintenance of these systems can be expensive, requiring the opening of concrete or other fixed structures. Electrically heated floors are available, and both kinds of systems can also be used in wood floors as well.

Problems with floors. Wood floors, particularly older ones, will tend to "squeak" in certain places. This is caused by the wood rubbing against other wood, usually at a joint of the subfloor. Firmly securing the pieces to each other with screws or nails may reduce this problem. Floor vibration is a problem with floors. Wood floors tend to pass sound, particularly heavy footsteps and low bass frequencies. Floating floors can reduce this problem. Concrete floors are usually so massive they do not have this problem, but they are also much more expensive to construct and must meet more stringent building requirements due to their weight. The flooring may need protection sometimes. A gym floor cover can be used to reduce the need to satisfy incompatible requirements.

Floor cleaning is a major occupation throughout the world and has been since ancient times. Cleaning is essential to prevent injuries due to slips and to remove dirt. Floors are also treated to protect or beautify the surface. The correct method to clean one type of floor can often damage another, so it is important to use the correct treatment.

The widespread popularity of carpets has inspired stories of the Magic carpet, a legendary carpet that can be used to transport persons who are on it instantaneously or quickly to their destination.

Text 5. Terrazzo

Terrazzo is a composite material, poured in place or precast, which is used for floor and wall treatments. It consists of marble, quartz, granite, glass, or other suitable chips, sprinkled or unsprinkled, and poured with a binder that is cementitious, chemical, or a combination of both. Terrazzo is cured and then ground and polished to a smooth surface or otherwise finished to produce a uniformly textured surface.

Terrazzo artisans create walkways, floors, patios, and panels by exposing marble chips and other fine aggregates on the surface of finished concrete or epoxy-resin. Much of the preliminary work of terrazzo workers is similar to that of cement masons. Marble-chip, cementitious terrazzo requires three layers of materials. First, cement masons or terrazzo workers build a solid, level concrete foundation that is three to four inches deep. After the forms are removed from the foundation, workers add a one-inch layer of sandy concrete. Before this layer sets, terrazzo workers partially embed metal divider strips in the concrete wherever there is to be a joint or change of color in the terrazzo. For the final layer, terrazzo workers blend and place into each of the panels a fine marble chip mixture that may be color-pigmented. While the mixture is still wet, workers toss additional marble chips of various colors into each panel and roll a weighted roller (100–125 lbs.) over the entire surface.

In the 1970s, polymer-based terrazzo was introduced and is called thin-set terrazzo. Initially polyester and vinyl ester resins were used as the binder resin.

Today, most of the terrazzo installed is epoxy terrazzo. The advantages of this material over cementitious terrazzo include a wider selection of colors, $\frac{1}{4}$ inch to $\frac{3}{8}$ inch installation thickness, lighter weight, faster installation, impermeable finish, higher strength, and less susceptibility to cracking. The disadvantage of epoxy resin–based terrazzo is that it can only be used for interior, not exterior, applications. Epoxy-based terrazzo will lose its color and slightly peel when used outdoors, whereas cement-based terrazzo will not. In addition to marble aggregate blends, other aggregates have been used, such as mother of pearl and abalone shell. Recycled aggregates include: glass, porcelain, concrete, and metal. Shapes and medallions can be fabricated on site by bending divider strips, or off site by water-jet cutting. When the terrazzo is thoroughly dry, helpers grind it with a terrazzo grinder, which is somewhat like a floor polisher, only much heavier. Slight depressions left by the grinding are filled with a matching grout material and hand-troweled for a smooth, uniform surface; it is then cleaned, polished, and sealed.

Terrazzo was originally invented by Venetian construction workers as a low cost flooring material using marble chips from upscale jobs. The workers would usually set them in clay to surface the patios around their living quarters. Consisting originally of marble chips, clay, and goat milk, production of terrazzo became much easier after the 1920s and the introduction of electric industrial grinders and other power equipment. Newly-set terrazzo will not look like marble unless it is wet. The goat's milk acts as a sealer and preserves the wet and marble-like look.

Archaeologists use the word *terrazzo* to describe the floors of early neolithic buildings in Western Asia, that are constructed of burnt lime and clay, colored red with ochre and polished. The embedded crushed limestone gives it a slightly mottled appearance. The use of fire to produce burnt lime, which was also used for the hafting of implements, predates the use of pottery by almost a thousand years. In the early Neolithic settlement of Cayönü in eastern Turkey ca. 90 m^2 of terrazzo floors have been uncovered. The floors of the PPN B settlement of Nevali Cori measure about 80 m^2. They are 15 cm thick, and contain about 10–15% lime. These floors are almost impenetrable to moisture and very durable, but their construction involved a high input of energy. Gourdin and Kingery estimate that the production of any given amount of lime requires about five times that amount of wood. Recent experiments by Affonso and Pernicka have shown that only twice the amount is needed, but that would still amount to 4.5 metric tons of dry wood for the floors in Cayönü. Other sites with terrazzo floors include Nevali Cori, Göbekli Tepe, Jericho, and Kastros (Cyprus).

Text 6. Ceramics for tiles

Ceramics for tiles include earthenware (terracotta), stoneware or porcelain. Stoneware is harder and more durable than earthenware, and so more suitable for floors. Terracotta is traditionally used for roof tiles, but other manufactured materials including types of concrete may now be used.

Roof tiles are designed mainly to keep out rain, and are traditionally made from locally available materials such as terracotta or slate. Modern materials such as concrete and plastic are also used and some clay tiles have a waterproof glaze. A large number of shapes (or "profiles") of roof tiles have evolved. These include:

Flat tiles – the simplest type, which are laid in regular overlapping rows. An example of this is the clay-made "beaver-tail" tile (German *Biberschwanz*), common in Southern Germany. Flat roof tiles are usually made of clay but also may be made of stone, wood, plastic, concrete, or solar cells.

Imbrex and tegula – an ancient Roman pattern of curved and flat tiles that make rain channels on a roof.

Roman tiles – flat in the middle, with a concave curve at one end at a convex curve at the other, to allow interlocking.

Pantiles – with an S-shaped profile, allowing adjacent tiles to interlock. These result in a ridged pattern resembling a ploughed field. An example of this is the "double Roman" tile, dating from the late 19th century in England and USA.

Mission or barrel tiles – semi-cylindrical tiles laid in alternating columns of convex and concave tiles. Originally they were made by forming clay around a curved surface, often a log or the maker's thigh. Today barrel tiles are mass-produced from clay, metal, concrete or plastic.

Interlocking roof tiles – similar to pantiles with side and top locking to improve protection from water and wind.

Antefixes – vertical blocks which terminate the covering tiles of a tiled roof.

Roof tiles are "hung" from the framework of a roof by fixing them with nails. The tiles are usually hung in parallel rows, with each row overlapping the row below it to exclude rainwater and to cover the nails that hold the row below. There are also roof tiles for special positions, particularly where the planes of the several pitches meet. They include ridge, hip and valley tiles. These can either be bedded and pointed in cement mortar or mechanically fixed. Similarly to roof tiling, tiling has been used to provide a protective weather envelope to the sides of timber frame buildings. These are hung on laths nailed to wall timbers, with tiles specially moulded to cover corners and jambs. Often these tiles are shaped at the exposed end to give a decorative effect. Another form of this is the so-called mathematical tile, which was hung on laths, nailed and then grouted. This form of tiling gives an imitation of brickwork and was developed to give the appearance of brick, but avoided the brick taxes of the 18th century. Slate roof tiles were traditional in some areas near sources of supply, and gave thin and light tiles when the slate was split into its natural layers. It is no longer a cheap material, however, and is now less common.

History. Fired roof tiles are found as early as the 3rd millennium BC in the Early Helladic *House of the tiles* in Lerna, Greece. Debris found at the site contained thousands of terracotta tiles having fallen from the roof. In the Mycenaean period, roofs tiles are documented for Gla and Midea. The earliest finds of roof tiles in archaic Greece are documented from a very restricted area around Corinth, where fired tiles began to replace thatched roofs at two temples of Apollo and Poseidon between 700 and 650 BC. Spreading rapidly, roof tiles were within fifty years in evidence for a large number of sites around the Eastern Mediterranean, including Mainland Greece, Western Asia Minor, and Southern and Central Italy. Early roof tiles showed an S-shape, with the pan and cover tile forming one piece. They were rather bulky affairs, weighing around 30 kg a piece. Being more expensive and labour-intensive to produce than thatch, their introduction has been explained by their greatly enhanced fire resistance, which gave desired protection to the costly temples.

The spread of the roof tile technique has to be viewed in connection with the simultaneous rise of monumental architecture in ancient Greece. Only the newly appearing stone walls, which were replacing the earlier mudbrick and wood walls, were strong enough to support the weight of a tiled roof. As a side-effect, it has been assumed that the new stone and tile construction also ushered in the end of “Chinese roof” (*Knickdach*) construction in Greek architecture, as they made the need for an extended roof as rain protection for the mudbrick walls obsolete. Production of dutch roof tiles started in the 14th century when city rulers required the use of fireproof materials. At the time, most houses were made of wood and had thatch roofing, which would often cause fires to quickly spread. To satisfy demand, many small roof tile makers began to produce roof tiles by hand. Many of these small factories were built near rivers where there was a ready source of clay and cheap transport.

Floor tiles. These are commonly made of ceramic or stone, although recent technological advances have resulted in rubber or glass tiles for floors as well. Ceramic tiles may be painted and glazed. Small mosaic tiles may be laid in various patterns. Floor tiles are typically set into mortar consisting of sand, cement and often a latex additive for extra adhesion. The spaces between the tiles are nowadays filled with sanded or unsanded floor grout, but traditionally mortar was used. Natural stone tiles can be beautiful but as a natural product they are less uniform in color and pattern, and require more planning for use and installation. Mass-produced stone tiles are uniform in width and length. Granite or marble tiles are sawn on both sides and then polished or finished on the facing up side, so that they have a uniform thickness. Other natural stone tiles such as slate are typically “riven” (split) on the facing up side so that the thickness of the tile varies slightly from one spot on the tile to another and from one tile to another. Variations in tile thickness can be handled by adjusting the amount of mortar under each part of the tile, by using wide grout lines that “ramp” between different thicknesses, or by using a cold chisel to knock off high spots.

Some stone tiles such as polished granite, marble, and travertine are very slippery when wet. Stone tiles with a riven (split) surface such as slate or with a sawn and then sandblasted or honed surface will be more slip resistant. Ceramic tiles for use in wet areas can be made more slip resistant either by using very small tiles so that the grout lines acts as grooves or by imprinting a contour pattern onto the face of the tile. The hardness of natural stone tiles varies such that some of the softer stone (e.g. limestone) tiles are not suitable for very heavy traffic floor areas. On the other hand, ceramic tiles typically have a glazed upper surface and when that becomes scratched or pitted the floor looks worn, whereas the same amount of wear on natural stone tiles will not show, or will be less noticeable.

Natural stone tiles can be stained by spilled liquids; they must be sealed and periodically resealed with a sealant in contrast to ceramic tiles which only need their grout lines sealed. However, because of the complex, non repeating patterns in natural stone, small amounts of dirt on many natural stone floor tiles do not show. The tendency of floor tiles to stain depends not only on a sealant being applied, and periodically re-applied, but also on their porosity or how porous the stone is. Slate is an example of a less porous stone while limestone is an example of a more porous stone. Different granites and marbles have different porosities with the less porous ones being more valued and more expensive. Most vendors of stone tiles emphasize that there will be variation in color and pattern from one batch of tiles to another of the same description and variation within the same batch. Stone floor tiles tend to be heavier than ceramic tiles and somewhat more prone to breakage during shipment. Rubber floor tiles have a variety of uses, both in residential and commercial settings. They are especially useful in situations where it is desired to have high-traction floors or protection for an easily breakable floor. Some common uses include flooring of garage, workshops, patios, swimming pool decks, sport courts, gyms, and dance floors. Plastic floor tiles including interlocking floor tiles that can be installed without adhesive or glue are a recent innovation and are suitable for areas subject to heavy traffic, wet areas and floors that are subject to movement, damp or contamination from oil, grease or other substances that may prevent adhesion to the substrate. Common uses include old factory floors, garages, gyms and sports complexes, schools and shops.

*Decorative tilework and coloured brick.*Decorative tilework should be distinguished from mosaic, where forms are made of great numbers of tiny irregularly positioned tesserae in a single colour, usually of glass or sometimes ceramic.The earliest evidence of glazed brick is the discovery of glazed bricks in the Elamite Temple at Chogha Zanbil, dated to the 13th century BC. Glazed and coloured bricks were used to make low reliefs in Ancient Mesopotamia, most famously the Ishtar Gate of Babylon (575 BC), now partly reconstructed in Berlin, with sections elsewhere. Mesopotamian craftsmen were imported for the palaces of the Persian Empire such as Persepolis.Tiling was widespread in the time of the Sinhalese kings of ancient Sri Lanka, using smoothed and polished stone laid on floors and in swimming pools. Historians consider the techniques and tools for tiling as well advanced, evidenced by the fine workmanship and close fit of the tiles. Tiling from this period can be seen Ruwanwelisaya and Kuttam Pokuna in the city of Anuradhapura.

Islamic tiles. Early Islamic mosaics in Persia consist mainly of geometric decorations in mosques and mausoleums, made of glazed brick. Typical turquoise tiling becomes popular in 10th-11th century and is used mostly for Kufic inscriptions on mosque walls. Seyed Mosque in Isfahan (1122 AD), Dome of Maraqeh (1147 AD) and the Jame Mosque of Gonabad (1212 AD) are among the finest examples. The dome of Jame' Atiq Mosque of Qazvin is also dated to this period. The golden age of Persian tilework began during the reign the Timurid Empire. Single color tiles were cut into small pieces and assembled by pouring liquid plaster between them. After hardening, these panels were assembled on the walls of buildings. But the mosaic was not limited to flat areas. Jame Mosque in Yazd (1324-1365 AD) and Goharshad Mosque (1418 AD) are prominent examples of brick and tile mosaics of interiors and external surfaces of domes. Islamic buildings in Bukhara (16^{th} -17th century) also exhibit very sophisticated floral ornaments. Mihrabs, being focus points of mosques, were usually the places where most sophisticated tilework was placed. The 14th century mihrab at Madrasa Imami in Isfahan is an outstanding example of aesthetic union between the Islamic calligrapher’s art and abstract ornament. The pointed arch, framing the mihrab’s niche, bears an inscription in Kufic script used in 9th-century Quran.

One of the best known architectural masterpieces of Iran is the Shah Mosque in Isfahan, from the 17th century. Its dome is a prime example of tile mosaic and its winter praying hall houses one of the finest ensembles of *cuerda seca* tiles in the world. Wide variety of tiles had to be manufactured in order to cover complex forms of the hall with consistent mosaic patterns. The result was a technological triumph as well as a dazzling display of abstract ornament. During the Safavid period mosaic ornaments vere often replaced by a *haft rang* (seven colors) technique. Pictures were painted on plain rectangle tiles, glazed and fired afterwards. Besides economic reasons, the seven colors method gave more freedom to artists and was less time-consuming. It was popular until Qajar period when the palette of colors was extended by yellow and orange. The

Persianate tradition continued and spread to much of the Islamic world, notably the İznik pottery of Turkey under the Ottoman Empire in the 16th and 17th centuries. Palaces, public buildings, mosques and türbe mausoleums were heavily decorated with large brightly coloured patterns, typically with floral motifs, and friezes of astonishing complexity, including floral motifs and calligraphy as well as geometric patterns. The zellige tradition of Arabic North Africa uses small coloured tiles of various shapes to make very complex geometric patterns. It is halfway to mosaic, but as the different shapes must be fitted precisely together, falls under tiling.

Western tilework. Medieval Europe made considerable use of painted tiles, sometimes producing very elaborate schemes, of which few have survived. Religious and secular stories were depicted. The imaginary tiles with Old testament scenes shown on the floor in Jan van Eyck's 1434 *Annunciation* in Washington are an example. The 14th century "Tring tiles" in the British Museum show childhood scenes from the *Life of Christ*, possibly for a wall rather than a floor, while their 13th century "Chertsey Tiles", though from an abbey, show scenes of Richard the Lionheart battling with Saladin in very high-quality work. Medieval letter tiles were used to create Christian inscriptions on church floors. Transmitted via Islamic Spain, a new tradition of azulejos developed in Spain and especially Portugal, which by the Baroque period produced extremely large painted scenes on tiles, usually in blue and white, for walls rather than floors. Delftware wall tiles, typically with a painted design covering only one (rather small) blue and white tile, were ubiquitous in Holland and widely exported over Northern Europe from the 16th century on, replacing many local industries. Several 18th century royal palaces had porcelain rooms with the walls entirely covered in porcelain in tiles or panels. Surviving examples include ones at Capodimonte, Naples, the Royal Palace of Madrid and the nearby Royal Palace of Aranjuez. There are several other types of traditional tiles that remain in manufacture, for example the small, almost mosaic, brightly coloured zellige tiles of Morocco and the surrounding countries. With exceptions, notably the Porcelain Tower of Nanjing, decorated tiles or glazed bricks do not feature largely in East Asian ceramics.

The Victorian period saw a great revival in tilework, largely as part of the Gothic Revival, but also the Arts and Crafts Movement. Patterned tiles, or tiles making up patterns, were now mass-produced by machine and reliably level for floors and cheap to produce, especially for churches, schools and public buildings, but also for domestic hallways and bathrooms. For many uses the tougher encaustic tile was used. Wall tiles in various styles also revived; the rise of the bathroom contributing greatly to this, as well as greater appreciation of the benefit of hygiene in kitchens. William De Morgan was the leading English designer working in tiles, strongly influenced by Islamic designs.

Since the Victorian period tiles have remained standard for kitchens and bathrooms, and many types of public area. Portugal and São Luís continue their tradition of *azulejo* tilework today. Notable among American tilemakers of the 1920s and 1930s were Ernest A. Batchelder and Pewabic Pottery.

Pebble tile. Similar to mosaics or other patterned tiles, pebble tiles are tiles made up of small pebbles attached to a backing. The tile is generally designed in an interlocking pattern so that final installations fit of multiple tiles fit together to have a seamless appearance. A relatively new tile design, pebble tiles were originally developed in Indonesia using pebbles found in various locations in the country. Today, pebble tiles feature all types of stones and pebbles from around the world.

Ceiling tiles are lightweight tiles used in the interior of buildings. They are placed in an aluminium grid and they provide little thermal insulation but are generally designed to improve the acoustics of a room. Mineral fibre tiles are fabricated from a range of products; wet felt tiles can be manufactured from perlite, mineral wool, and fibers from recycled paper, stonewool tiles are created by combining molten stone and binders which is then spun to create the tile, or gypsum tiles which are based on the soft mineral and then finished with vinyl, paper or a decorative face.

Ceiling tiles very often have patterns on the front face; these are there in most circumstances to aid with the tiles ability to improve acoustics. Ceiling tiles also provide a barrier to the spread of smoke and fire. Breaking, displacing, or removing ceiling tiles enables hot gases and smoke from a fire to rise and accumulate above detectors and sprinklers. Doing so delays their activation, enabling fires to grow more rapidly. Ceiling tiles, especially in old Mediterranean houses were made of terracotta and were placed on top of the wooden ceiling beams and upon those were placed the roof tiles. They were then plastered or painted, but nowadays are usually left bare for decorative purposes. Modern-day tile ceilings may be flush mounted (nail up or glue up) or installed as dropped ceilings.

Digital tile. Printing techniques and digital manipulation of art and photography are used in what is known as "custom tile printing". Dye sublimation printers, inkjet printers and ceramic inks and toners permit printing on a variety of tile types yielding photographic-quality reproduction.Using digital image capture via scanning or digital cameras, bitmap / raster images can be prepared in Photoshop and other photo editing software programs. Specialized custom-tile printing techniques permit transfer under heat and pressure or the use of high temperature kilns to fuse the picture to the tile substrate. This has become an increasingly popular method of producing custom tile murals for kitchens, showers, and commercial decoration in restaurants, hotels, and corporate lobbies.

Diamond etched tiles. A new method for custom tile printing involving a diamond-tipped drill controlled by a special type of computer. Compared with the laser engravings, diamond etching is in almost every circumstance more permanent.

Text 7. Plaster

Plaster is a building material used for coating walls and ceilings. Plaster is manufactured as a dry powder and is mixed with water to form a paste when used. The reaction with water liberates heat through crystallization and the hydrated plaster then hardens. Plaster can be relatively easily worked with metal tools or even sandpaper. These characteristics make plaster suitable for a finishing, rather than a load-bearing material. The term plaster can refer to gypsum plaster (also known as *plaster of Paris*), lime plaster, or cement plaster.

Gypsum plaster (plaster of Paris). Gypsum plaster, or plaster of Paris, is produced by heating gypsum to about 300 °F (150 °C).

When the dry plaster powder is mixed with water, it re-forms into gypsum. The setting of unmodified plaster starts about 10 minutes after mixing and is complete in about 45 minutes; but not fully set for 72 hours. If plaster or gypsum is heated above 392°F (200°C), anhydrite is formed, which will also re-form as gypsum if mixed with water. A large gypsum deposit at Montmartre in Paris led "calcined gypsum" (roasted gypsum or gypsum plaster) to be commonly known as "plaster of Paris". Plasterers often use gypsum to simulate the appearance of surfaces of wood, stone, or metal, on movie and theatrical sets for example. Nowadays, theatrical plasterers often use expanded polystyrene, although the job title remains unchanged. Plaster of Paris can be used to impregnate gauze bandages to make a sculpting material called modroc. It is used similarly to clay, as it is easily shaped when wet, yet sets into a resilient and lightweight structure. This is the material that was used to make classic plaster orthopedic casts to protect limbs with broken bones, the medical use having been partly inspired by the artistic use. Set modroc is an early example of a composite material.

Technical details. Depending on the temperature and duration of the heating process, gypsum converts to the hemihydrate or an anhydrous form. Two polymorphs are known of the hemihydrate. The anhydrous calcium sulfate occurs in three forms, called anhydrite I, II, and III. Each form hydrates differently. The hemihydrate converts to the dihydrate. The anhydrite III converted via the hemihydrate, whereas anhydrite II is converted directly into dihydrate without forming intermediates.

Lime plaster. Lime plaster is a mixture of calcium hydroxide and sand (or other inert fillers). Carbon dioxide in the atmosphere causes the plaster to set by transforming the calcium hydroxide into calcium carbonate (limestone). Whitewash is based on the same chemistry. To make lime plaster, limestone (calcium carbonate) is heated to produce quicklime (calcium oxide). Water is then added to produce slaked lime (calcium hydroxide), which is sold as a wet putty or a white powder. Additional water is added to form a paste prior to use. The paste may be stored in air-tight containers. When exposed to the atmosphere, the calcium hydroxide very slowly turns back into calcium carbonate through reaction with atmospheric carbon dioxide, causing the plaster to increase in strength. Lime plaster was a common building material for wall surfaces in a process known as lath and plaster, whereby a series of wooden strips on a studwork frame was covered with a semi-dry plaster that hardened into a surface. The plaster used in most lath and plaster construction was mainly lime plaster, with a cure time of about a month. To stabilize the lime plaster during curing, small amounts of plaster of Paris were incorporated into the mix. Because plaster of Paris sets quickly, "retardants" were used to slow setting time enough to allow workers to mix large working quantities of lime putty plaster. A modern form of this method uses expanded metal mesh over wood or metal structures, which allows a great freedom of design as it is adaptable to both simple and compound curves. Today this building method has been partly replaced with drywall, also composed mostly of gypsum plaster. In both these methods a primary advantage of the material is that it is resistant to a fire within a room and so can assist in reducing or eliminating structural damage or destruction provided the fire is promptly extinguished. Lime plaster is used for frescoes, where pigments, diluted in water, are applied to the still wet plaster. USA and Iran are the main plaster producers in the world.

Cement plaster. Cement plaster is a mixture of suitable plaster, sand, portland cement and water which is normally applied to masonry interiors and exteriors to achieve a smooth surface. Interior surfaces sometimes receive a final layer of gypsum plaster. Walls constructed with stock bricks are normally plastered while face brick walls are not plastered. Various cement-based plasters are also used as proprietary spray fireproofing products. These usually use vermiculite as lightweight aggregate. Heavy versions of such plasters are also in use for exterior fireproofing, to protect LPG vessels, pipe bridges and vessel skirts. Cement plaster was first introduced in America around 1909 and was often called by the generic name *adamamant plaster* after a prominent manufacturer of the time. The advantages of cement plaster noted at that time were its strength, hardness, quick setting time and durability.

Plaster may also be used to create complex detailing for use in room interiors. These may be geometric (simulating wood or stone) or naturalistic (simulating leaves, vines, and flowers) These are also often used to simulate wood or stone detailing found in more substantial buildings.

In art. Many of the greatest mural paintings in Europe, like Michelangelo's Sistine Chapel ceiling are executed in fresco, meaning they are painted on a thin layer of wet plaster, called intonaco; the pigments sink into this layer so that the plaster itself becomes the medium holding them, which accounts for the excellent durability of fresco. Additional work may be added *a secco* on top of the dry plaster, though this is generally less durable. Plaster may be cast directly into a damp clay mold. In creating this *piece molds* (molds designed for making multiple copies) or *waste molds* (for single use) would be made of plaster. This "negative" image, if properly designed, may be used to produce clay productions, which when fired in a kiln become terra cotta building decorations, or these may be used to create cast concrete sculptures. If a plaster positive was desired this would be constructed or cast to form a durable image artwork. As a model for stonecutters this would be sufficient. If intended for producing a bronze casting the plaster positive could be further worked to produce smooth surfaces. An advantage of this plaster image is that it is relatively cheap; should a patron approve of the durable image and be willing to bear further expense, subsequent molds could be made for the creation of a wax image to be used in lost wax casting, a far more expensive process. In lieu of producing a bronze image suitable for outdoor use the plaster image may be painted to resemble a metal image; such sculptures are suitable only for presentation in a weather-protected environment.

Plaster expands while hardening, then contracts slightly just before hardening completely. This makes plaster excellent for use in molds, and it is often used as an artistic material for casting. Plaster is also commonly spread over an armature (form), usually made of wire, mesh or other materials, a process raised details. For these processes, limestone or acrylic based plaster may be employed.

In fire protection. Plasters have been in use in passive fire protection, as fireproofing products, for many decades. The finished plaster releases water vapor when exposed to flame, acting to slow the spread of the fire, for as much as an hour or two depending on thickness. It also provides some insulation to retard heat flow into structural steel elements, that would otherwise lose their strength and collapse in a fire. Early versions of these plasters have used asbestos fibres, which have by now been outlawed in industrialized nations and have caused significant removal and re-coating work. More modern plasters fall into the following categories: 1) fibrous (including mineral wool and glass fiber), 2) cement mixtures either with mineral wool or with vermiculite, 3) gypsum plasters, leavened with polystyrene beads, as well as chemical expansion agents to decrease the density of the finished product.

One differentiates between interior and exterior fireproofing. Interior products are typically less substantial, with lower densities and lower cost. Exterior products have to withstand more extreme fire and other environmental conditions. Exterior products are also more likely to be attractively tooled, whereas their interior cousins are usually merely sprayed in place. A rough surface is typically forgiven inside of buildings as dropped ceilings often hide them. Exterior fireproofing plasters are losing ground to more costly intumescent and endothermic products, simply on technical merit. Trade jurisdiction on unionized construction sites in North America remains with the plasterers, regardless of whether the plaster is decorative in nature or is used in passive fire protection. Cementitious and gypsum based plasters tend to be endothermic. Fireproofing plasters are closely related to firestop mortars. Most firestop mortars can be sprayed and tooled very well, due to the fine detail work that is required of firestopping, which leads their mix designers to utilise concrete admixtures, that enable easier tooling than common mortars.

In Industry. It is used in glass making, tanning, bleaching powder making and purification of sugar.

Safety issues. The chemical reaction that occurs when plaster is mixed with water is exothermic in nature and, in large volumes, can burn the skin. In January 2007, a student sustained third-degree burns after encasing her hands in a bucket of plaster as part of a school art project. The burns were so severe she required amputation of both her thumbs and six of her fingers. Some variations of plaster that contain powdered silica or asbestos may present health hazards if inhaled. Asbestos is a known irritant when inhaled in powder form can cause cancer, especially in people who smoke, and inhalation can also cause asbestosis. Inhaled silica can cause silicosis and (in very rare cases) can encourage the development of cancer. Persons working regularly with plaster containing these additives should take precautions to avoid inhaling powdered plaster, cured or uncured.

VOCABULARY

acrylic resin – акриловая синтетическая смола,
adamant – твердый минерал или металл,
additive – примесь, добавка к топливу,
adhesion – прилипание, сцепление,
adhesive – липкий, клейкий, связывающий,
adjacent – примыкающий, смежный, соседний,
adjust – приспосабливать, устанавливать,
admixture – примесь, смешивание,
adobe – необоженный кирпич, саманная / глинобитная постройка,
afterwards – впоследствии, потом, позже,
aggregate – агрегат, собирать,
airtight – герметический,
alternating – переменный,
amount – количество, сумма,
anhydrite – ангидрит *(минерал класса сульфатов, поглощая воду, переходит в гипс)*,
anhydrous – безводный,
Apollo – Аполлон *(в греческой мифологии сын Зевса, покровитель искусств, изображался прекрасным юношей с луком или кифарой),*
archaic – архаический, устаревший,
armature – арматура,
artisan – ремесленник, мастеровой,
asbestos – асбест *(минерал класса силикатов, материал для огнестойких и теплоизоляционных изделий),*
assemble – собирать,
assume – принимать форму,
attach – прикреплять, придавать,
available – доступный,
Babylon – Вавилон *(древний город в Месопотамии),*
bandage – бинт, перевязывать,
barrel – баррель *(мера жидких, сыпучих и некоторых твердых материалов),*
batch – пачка, кучка,
bead – шарик, бусинка,
beaver-tail – бобровый хвост,
bed – настилать, класть на надлежащее основание,
benefit – выгода, польза, прибыль,
binder – связующее вещество,
bleaching powder – белильная / хлорная известь,
blend – смесь, переход одного цвета или оттенка в другой,

bubble – пузырь, пузырек,
bulky – большой, объемистый,
calcine – кальцинировать, пережигать или превращать в известь,
calcium – кальций,
capture – захватывать, поглощать,
carbonate – углекислая соль, карбонат,
cast – форма для отливки, гипсовый слепок,
ceiling – потолок,
cement – цемент,
ceramics – керамика, гончарное производство,
chapel – часовня,
chip – обломок, щебень,
chisel – резец, долото,стамеска, зубило,
circumstance – обстоятельство,
coating – слой, шпаклевка, грунт,
collapse – обвал, разрушение, продольный изгиб,
composite – смесь, составной, сложный,
concave – вогнутый, впалый, впадина, свод,
concrete – бетон,
contamination – загрязнение,
contour – контур, очертание, абрис,
convert – превращать, переделывать,
convex – выпуклый,
Corinthian – коринфский (ордер),
covering – оболочка, облицовка, настил, покрытие,
cracking – крекинг,
craftsman – мастер, ремесленник,
cure – вулканизация (резины),
curing – консервирование, заготовка,
curve – кривая, изгиб, гнуть,
dazzle – ослеплять, маскировать,
decrease – уменьшение, спад,
dehydration – обезвоживание,
delft – (дельфтский) фаянс,
density – густота, плотность,
depict – рисовать, изображать,
deposit – осадок, месторождение,
depression – снижение, падение, вакуум,
destruction – разрушение, уничтожение,
detector – индикатор,
dextrin – декстрин,
dilute – разжижать, разбавленный,

dimple – впадина,
disperse – рассеивать, разбрасывать,
drill – сверло, сверлить, бурить,
duct – трубопровод, труба,
durability – прочность, долговечность,
duration – продолжительность,
earthenware – глиняная посуда, керамика, глиняный,
elaborate – тщательно разработанный, разрабатывать,
eliminate – устранять, исключать, очищать,
embed – вставлять, врезать,
emerge – появляться, всплывать,
emphasize – подчеркивать, акцентировать,
employ – употреблять, применять,
enable – создавать возможность, облегчать,
encaustic tile – разноцветный изразец,
endurance – прочность, длительность,
engraving – гравюра, гравирование,
enhance – увеличивать, повышать,
ensemble – ансамбль, общее впечатление,
environment – окружающая обстановка,
equipment – оборудование, арматура,
ester – сложный эфир,
etch – гравировать,
evidence – основание, признаки,
evolve – развивать, выделять,
exclude – исключать,
expand – расширять, увеличивать в объеме,
extinguish – гасить, тушить, уничтожать,
fibre – волокно, нить,
finishing – отделка,
fireproof – несгораемый, огнеупорный,
flame – пламя, гореть,
floral – растительный, цветочный,
flush – прилив, краска, полный, наполнять,
fresco – фреска, украшать фресками,
fuse – плавка, плавить,
gauze – газ, металлическая сетка, дымка,
gentry – мягко, нежно,
glaze – глазурь, глянец,
glue – клей, клеить,
grating – решетка,
grease – смазочное вещество, смазывать,

grid – решетка,
grind – размалывание, молоть,
groove – желобок, паз,
grout – жидкий раствор, заливать раствором,
gypsym – гипс,
haft – черенок, рукоятка, ручка,
hallway – коридор, прихожая,
harden – твердеть, застывать,
hardness – твердость, прочность,
hazard – риск, опасность,
hip – конек, ребро крыши,
hone – точить, хонинговать,
hydroxide – гидроокись, гидрат окиси,
imbrex – желобчатая черепица,
imperfection – недостаток, дефект,
impermeable – непроницаемый, герметический,
impregnate – наполнять, внедрять,
imprinting – импринтинг, отпечаток,
inhalation – вдыхание, ингаляция,
inhale – вдыхать,
interlock – соединять, сцеплять,
intermediate – промежуточный,
intumescence – распухание,
jamb – косяк (двери, окна), массив пустой породы,
joint – место соединения, стык,
kiln – печь для обжига и для сушки,
latex – латекс,
lath – планка, рейка,
laundry – прачечная,
layer – слой, пласт, класть пластами,
leaven – влиять,
length – длина,
liberate – освобождать, выделять,
lieu (in lieu of) – вместо,
limb – конечность, член (тела),
lime – известь,
limestone – известняк,
liquid – жидкость,
load – груз,
log – бревно, полено,
mason – каменщик, вести кладку,
masonry – каменная кладка,

masterpiece – шедевр,
mausoleum – мавзолей,
merely – только, просто,
merit – заслуга, качество,
mesh – петля, ячейка сети, сцеплять,
mix – смесь, смешивать,
mold (mould) – литейная форма, отливать в форму,
molten – расплавленный, литой,
mortise – паз, долбить,
mosque – мечеть,
mottle – крапинка, пятнышко, испещрять,
multiple – составной,многочисленный,
mural – стенной, отвесный, фреска,
Mycenaean period – микенский период,
nail – гвоздь, забивать гвозди, прибивать,
notably – достопримечательный, выдающийся, заметный, выдающийся человек,
obsolete – вышедший из употребления, устарелый, изношенный,
ornament – украшение, орнамент, украшать, быть украшенным,
orthopedic – ортопедический,
outlaw – человек находящийся вне закона, объявлять кого-либо вне закона, лишать законной силы,
overlap – частично покрывать, заходить один за другой, перекрывать,
palette – паллет, поддон, лопаточка, шпатель,
pantile – голландская черепица, конковая черепица,
paste – мастика, клей, клейстер, стекловидная масса, мятая глина,
patio – внутренний дворик,
patron – патрон, клиент,
pebble – голыш, галька, булыжник, мостить булыжником, посыпать галькой,
peel – четырехугольная башня на границе Англии и Шотландии,
permanent – постоянный, неизменный, долговременный,
permit – позволять, разрешать, допускать, разрешение,
pigment –пигмент,
pillar – столб, колонна, стойка, опора, подпирать, поддерживать,
pipe – труба, трубопровод, снабжать трубами, пускать по трубам,
pitch – разбивать , ставить, мостить брусчаткой, бросать, падение,
pit – яма, шахта, карьер, рыть ямы,
plain –ясный, очевидный, прямой,
plaster – гибс, алебастр, штукатурить, покрывать, подмешивать гипс,
ploughed field – вспаханное поле,
plywood – (клееная) фанера,

polystyrene – полистрол,
porcelain – фарфор, фарфоровый, фарфоровая глина,
porous – пористый, губчатое железо,
porosity –пористость,
pottery – глиняные изделия, фаянс,
powder – порошок, пыль, превращать в порошок,
precast – заводского изготовления, сборного типа,
precaution – предосторожность,
predate – произойти до какого-либо числа,
preliminary – предварительный,
prior – прежний, предшествующий,
prominent – выступающий, выпуклый, рельефный,
prone – распростерстый, покатый,
proprietary – частный, патентованное средство,
purification – очищение, очистка,
putty – замазка, шпатлевка, замазывать,
ramp – скат, уклон, наклонная плоскость,
rapidly – быстро,
rectangle – прямоугольник,
relatively – относительно, сравнительно,
release – освобождать, расцеплять,
removal – удаление, выемка,
resemble – походить, иметь сходство,
resilient – упругий, эластичный,
restrict – ограничивать,
retard – задерживать, тормозить,
revival – возрождение, восстановление,
ridge – конек (крыши), край, ребро,
riven – расколотый,
roast – обжиг, обжигать, кальцинировать,
roll – рулон,
rotary – вращательный, ротационный,
rough – неровный, шершавый,
rubber – резина, каучук,
sag – прогиб, свисать, покоситься,
sandblast – струя песка, обдувать песочной струей,
sandpaper – наждачная бумага,
saw – пилить, распиливать,
scanning – сканирование,
scratch – царапина, царапать,
seal – печать, клеймо, изоляция,
seamless – безшовный,

secular – вечный,
sheeting – защитное покрытие,
shipment – отправка, перевозка товаров,
silica – кремнезем, кварц,
simulate – имитировать, подделывать,
simultaneous – одновременный,
sink – опускаться, проникать, оседать,
slab – плита, пластина, мостить плитами,
slaked lime – гашеная известь,
slate – сланец, шифер,
slippery – скользкий,
smooth – однородный, гладкий,
solar – солнечный,
solid – твердый, сплошной,
sophisticate – придавать утонченность, подделывать,
spot – пятно,
spray (sprayed) – пульверизатор, распылять,
sprinkle – брызгать,
stain – пятно, краска,
stonecutter – каменотес,
stoneware – керамические изделия, глиняная посуда,
strength – прочность, сопротивление,
strip – разбирать, демонтировать, полоса, лента,
sublimation – сублимация, очищение,
subsequent – последующий,
substantial – существенный, важный,
suitable – подходящий, соответствующий,
surface – поверхность, отделывать поверхность,
susceptibility – впечатлительность, восприимчивость,
tapestry – гобелен,
tax – подвергать испытанию,
tegular – черепичный,
temple – храм, прижимная планка,
tenon – шпилька, шип,
terminate – положить конец, завершаться, ограничивать,
terra cotta – терракота, терракотовый,
tesserae – кубик (в мозаике),
testament – завет,
thatched roof – соломенная крыша,
thickness – толщина, слой,
thigh – бедро,
thin – тонкий, прозрачный, тусклый,

tile – черепица, кафель, изразец, плитка,
tool – рабочий инструмент, резец,
toss – бросать, кидать,
transmit – передавать, отправлять,
travertine – травертин, известковый туф,
treatment – обработка, пропитка,
trowel – кельма, мастерок, разглаживать кельмой,
turquoise – бирюза, бирюзовый цвет,
ubiquitous – повсеместный,
usher – проводить,
utilize – использовать, утилизировать,
varnish – лак, лакировать,
vendor – продавец,
walkway – дорожка, аллея,
waterproof – водонепроницаемый,
wax – воск, вощить,
whitewash – известковый раствор, побелка,
widespread – широкораспространенный,
width – ширина, пролет,
wire – проволока, связывать,
withstand – выдержать,
workshop – мастерская, цех,
yielding – мягкий, податливый.

ЗАКЛЮЧЕНИЕ

Учебное пособие предназначено для всех студентов, обучающихся на строительных специальностях.

Пособие содержит современные аутентичные тексты по строительной тематике, предназначенные как для работы на занятиях, так и во внеаудиторное время.

Данный материал является необходимым для формирования навыков понимания текстов по строительной тематике на английском языке и выполнению адекватного перевода. Трудности понимания предлагаемого материала снимаются благодаря использованию авторами англо-язычного материала.

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