Masonry wall construction

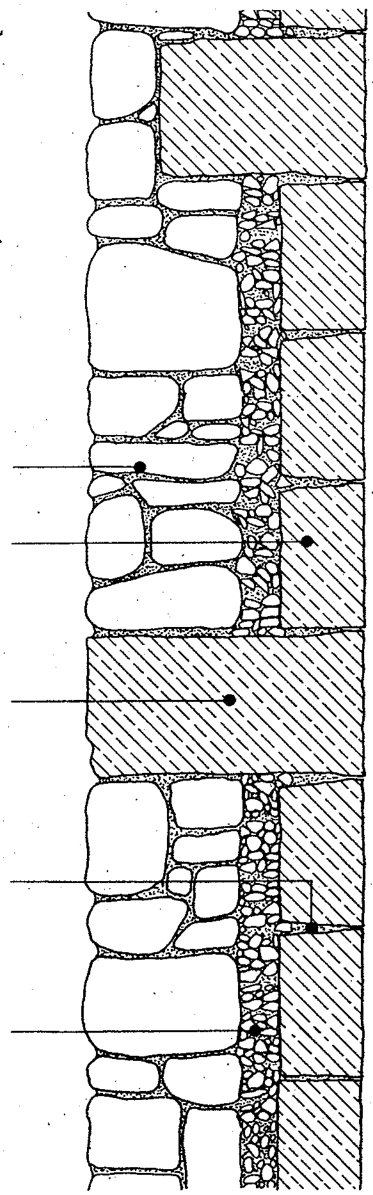
INTRODUCTION

This sheet describes the construction of external rubble and ashlar walls in the New Town. Defects common to 'Walls in General' are summarised in MM Sheet 2.01/2 which also gives further references for more detailed information.

MM Sheet 2.01/2, Stone Decay and Defects.

GENERAL CONSTRUCTION OF EXTERNAL WALLS

External masonry walls usually consisted of two distinct skins of bonded stonework separated by a filled "cavity" of consolidated stone chippings. In some cases, the cavity filling was omitted and the flanking skins built in direct contact with each other. It was common practice to construct "compound walls", that is, walls faced with blocks of ashlar combined with a backing of cheaper material such as rubble.



SECTION THROUGH TYPICAL RUBBLE AND ASHLAR COMPOUND WALL

The Internal skin was normally constructed of random rubble and finished with lath and plaster.

The External skin of street or front elevations was normally constructed of carefully dressed ashlar and, on rear elevations, of coursed random or squared rubble.

Bonding Stones connecting both skins of masonry, provide lateral stabilisation. 'THROUGHS' extend the full thickness of the wall whereas 'HEADERS' tie only part way into the internal skin.

Joints in ashlar were often worked "hollow" and filled with a coarse, lime/ sand mortar. For further information on mortar, jointing and pointing for both ashlar and rubble-work, refer to MM Sheet 2.01/8.

MM Sheet 2.01/8, Mortar Joints.

The Cavity Filling normally consisted of stone chippings (from the banker), which were grouted up with lime mortar left over at the end of each day's work.

RUBBLE

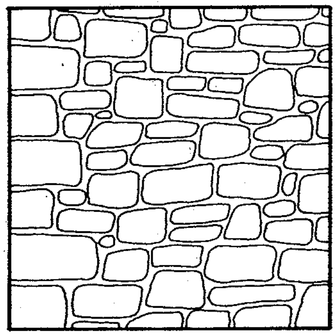
Rubble work consists of undressed or roughly dressed blocks of stone with wide joints. Walls or skins of walls may be built of coursed or uncoursed, random or squared rubble. Rubble masonry was often used for gable and rear elevation walls as well as internal load-bearing walls, party walls, garden walls, area-retaining walls and the inner skins of compound external walls.

1. Random Rubble

The stones used for random rubble work are often walled in their quarried state. Although smooth "self faced" blocks require no dressing, other stones may be roughly "hammer-faced" by means of a mash hammer.

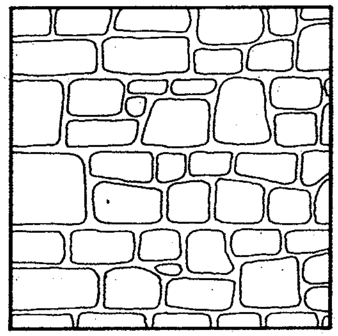
Unlike those used for ashlar (see below), rubble stones are not of uniform size or shape and great skill is needed to ensure adequate bonding, both transversely and longitudinally. 'Headers' and 'Throughs' are used liberally and long continuous vertical joints avoided. It is strongly recommended that the top bed of all stones has a slight fall outwards to the face of the wall. Random rubble can be built "uncoursed" or "coursed".

a) Uncoursed Random Rubble is the roughest and cheapest form of stone walling. The wall is built to form the strongest bond from haphazardly-sized materials and any inconvenient corners or excrescences are knocked off as necessary. Larger blocks are level-bedded and wedged with small pieces of stone or "spalls" with no attempt made to form accurate vertical or horizontal joints. Quoins and jambs are usually constructed with larger or more regular stones.



UNCOURSED
RANDOM RUBBLE

b) Coursed Random Rubble is similar to the above, excepting that the work is roughly levelled up to form courses varying from 300-450 mm high. These courses usually coincide with the varying heights of the quoin and jamb stones.

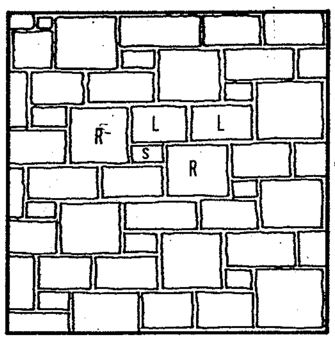


COURSED
RANDOM RUBBLE

2. Squared Rubble

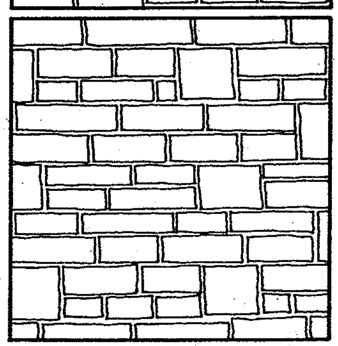
The blocks used for squared Rubble Work are usually quarried from thin beds of stone. The stones can then be squared with relative ease and brought to a "hammer-dressed" or "straight-cut" finish. Squared rubble can be "uncoursed", "coursed" or "regular-coursed".

a) Uncoursed Squared Rubble is otherwise known as "square-snecked rubble". Walls are commonly built to a distinct pattern based on a "unit" of four stones, i.e. a large bonding or through stone called a "riser", 2 thinner stones or "levellers" and a small stone termed a "sneck". The vertical joint between each pair of "levellers" is more or less central over a "riser". Adjacent "risers" are separated by a "sneck" to prevent the occurrence of long, continuous, vertical joints.



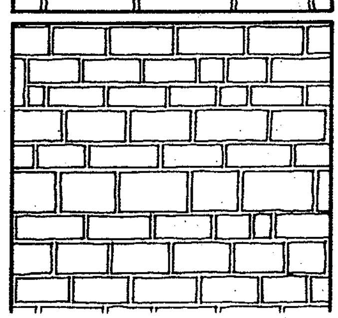
R = Riser
L = Leveller
S = Sneck
UNCOURSED
SQUARED RUBBLE

b) Coursed Squared Rubble is levelled up to courses of varying depth. Each course may consist of quoins, jamb stones, bonders and throughs of the same height with smaller stones built up between them to complete the course.



COURSED
SQUARED RUBBLE

c) Regular-coursed Squared Rubble is built in courses of varying depth but the stones in



REGULAR-COURSED

ASHLAR

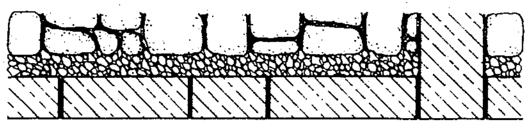
Ashlar is defined as masonry consisting of blocks of stone, finely dressed to given dimensions and laid in courses with thin joints. The thickness of the joints is often only 3 mm.

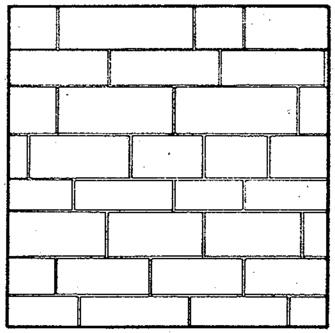
AJ Stone Handbook.

Ashlar is the most expensive and sophisticated grade of masonry and became one of the principal status symbols of building in the Georgian era. As such, it was applied selectively in the construction of New Town buildings, its use reserved mainly for facing external walls on street or front elevations. For this purpose, ashlar was used increasingly as the First New Town developed westwards and universally for New Town houses built after 1800. The facing was effectively tied to its backing by bonding stones (see above). Modern use of ashlar (e.g. as Indents), relies on mechanical fixings (cramps, dowels, anchor-bolts etc) for stability.

MM Sheet 2.01/9, Stone Repair by Indenting.

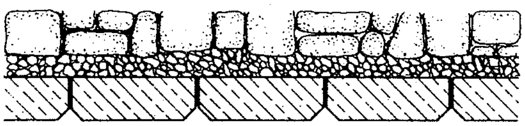
The face arrangement of ashlar generally resembles that of regular-coursed squared rubble although the joints are finer and more precise. The lengths of ashlar blocks can vary considerably and great care must be exercised to ensure good bonding, particularly when replacing or repairing large areas of defective masonry.

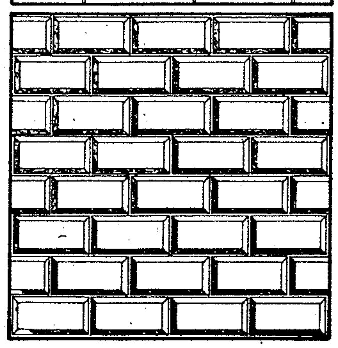




POLISHED ASHLAR

The ground floor of many New Town Georgian buildings is emphasised on its main elevation by the use of rusticated V-jointed ashlar. The margins of individual stones are chamfered to form V-shaped channels along the joints.



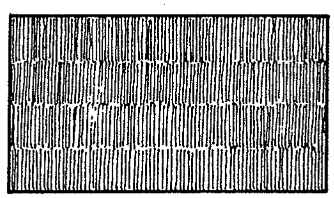


RUSTICATED V-JOINTED ASHLAR

Surface finishes to ashlar blocks are many and varied. High-quality masonry is constructed from blocks with smoothly finished, polished faces. This is accomplished by the abrasive action of carborundum, sand and water - an operation originally done by hand but which now employs mechanical 'rubbing beds'. The more elaborate finishes of droved, stugged, broached and rock-faced ashlar are also common to the New Town.

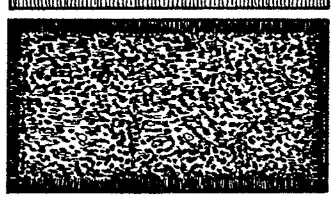
Building Construction Volume I. W B McKay.

A droved finish is produced by a hammer and boaster to form a series of 35 - 50 mm wide bands of more or less parallel tool marks. It is commonly applied to relatively inexpensive work.



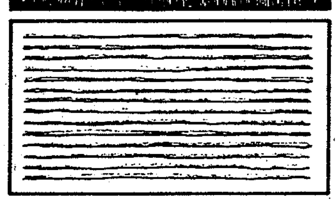
DROVED ASHLAR FINISH

A stugged finish is produced by forming depressions on the rough stone surface with a mason's punch. A droved margin is often worked on individual stones.



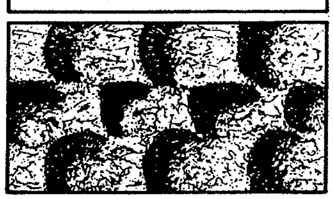
STUGGED ASHLAR FINISH

A broached finish is produced by either a toothed tool or a gouge to form a series of equally-spaced horizontal (or vertical) furrows. Individual stones treated in this way usually exhibit chisel-drafted margins, the furrows being stopped 15 - 30 mm short of the dressed edges.



BROACHED ASHLAR FINISH

A rock-faced finish is produced by a Pincher to form a rugged, deeply profiled surface of semi-regular design. The basements of street elevations are commonly treated with rock-faced ashlar.



ROCK-FACED ASHLAR FINISH

SPECIAL FEATURES

1. Blocking Courses and Parapets

A blocking course is a plain course of stone which surmounts a cornice in order to disguise the presence of a wallhead gutter. A low wall above a cornice at roof level is usually referred to as a parapet. Blocking courses and parapets are discussed in MM Sheet 3.07/1.

2. Cornices

A cornice is a projecting moulded course which is usually built near the top of a wall. Its object is to discharge water clear of the building and, as part of the classical entablature, it also provides an important architectural feature.

Cornices vary considerably in detail. The upper surface should be 'weathered' to encourage water run-off and the joints 'saddled' to prevent water entering them. An alternative is to flash the cornice with lead (although this is not an authentic detail in the New Town). Vertical joints should be 'joggled' to impart stability and rigidity. Cornices are a common source of moisture penetration and are very prone to decay. Their repair is discussed in MM Sheet 2.01/10.

3. Friezes

A frieze is a stone course surmounted by a cornice. Emphasis may be given to a frieze by projecting it slightly, especially if there is not a string course or architrave immediately below it.

4. String Courses

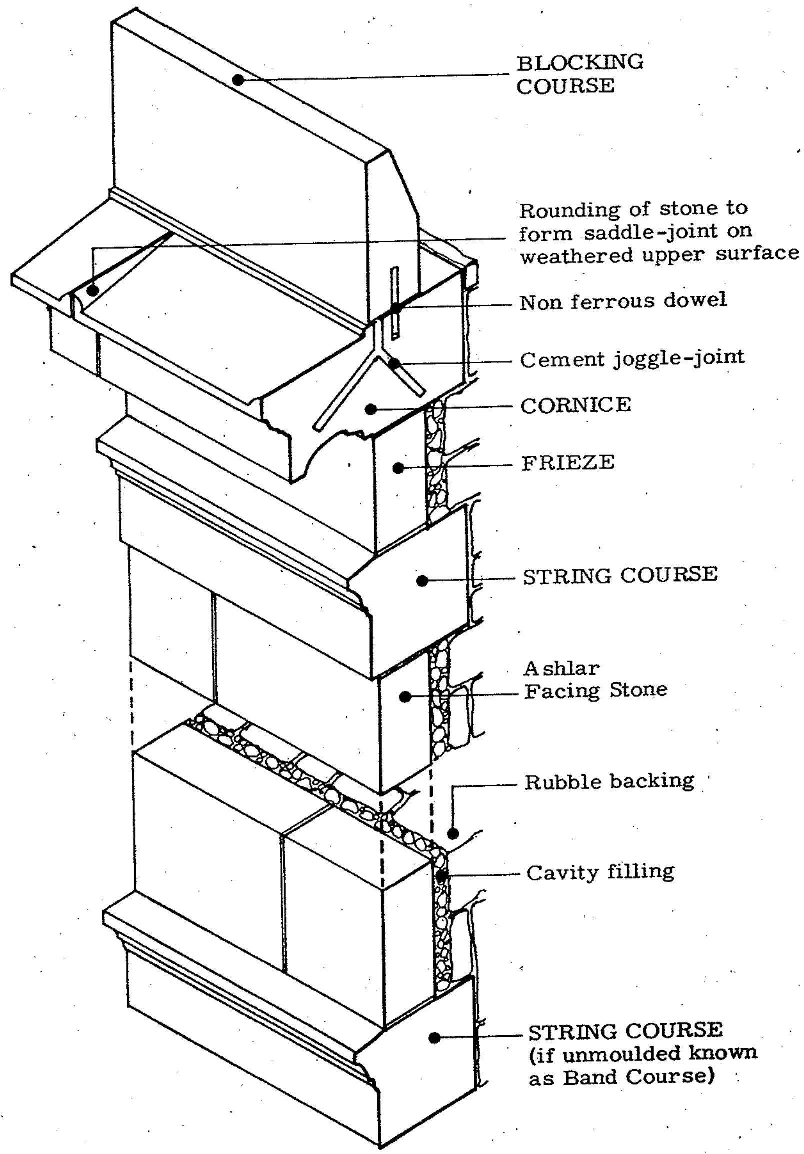
A string course is a horizontal course of masonry which projects as an architectural feature. It is usually constructed of bonding stones.

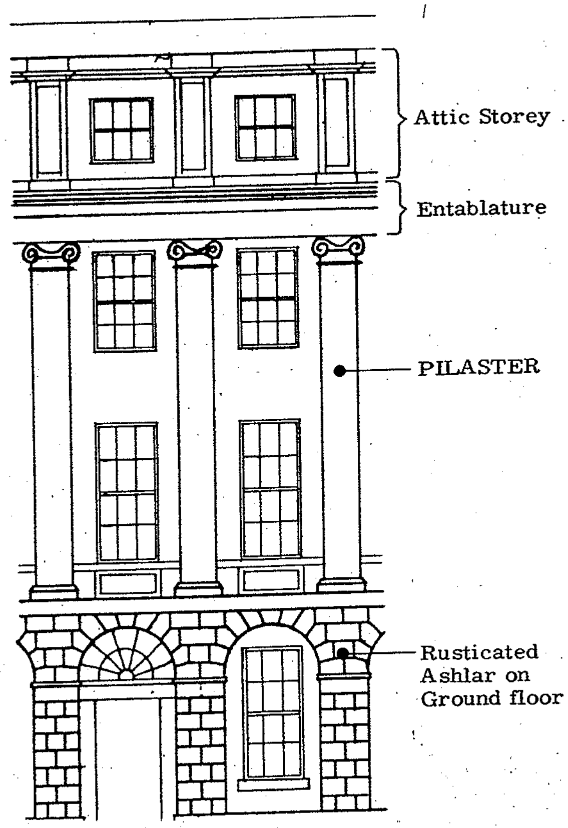
5. Pilasters

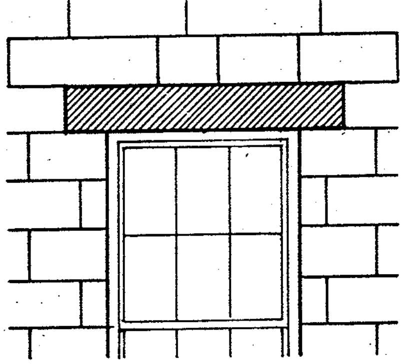
A pilaster is a shallow, pier-like, rectangular column of classical proportions applied to the face of the wall. A pilaster strip is one with no base or cap. Pilasters can most commonly be seen on the pavilion and centre blocks of terraces or on the more prestigious developments in the New Town. They add vertical emphasis to the upper storeys of a building by extending from above the rusticated ashlar of the ground floor to the entablature at roof or attic storey level. Pilasters may also be built around door openings. (see below).

6. Wall openings

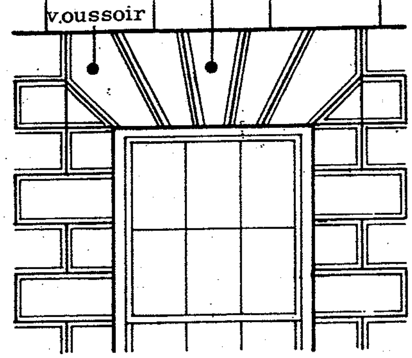
see drawings opposite and text overleaf.



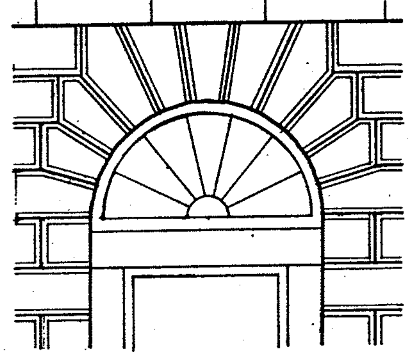




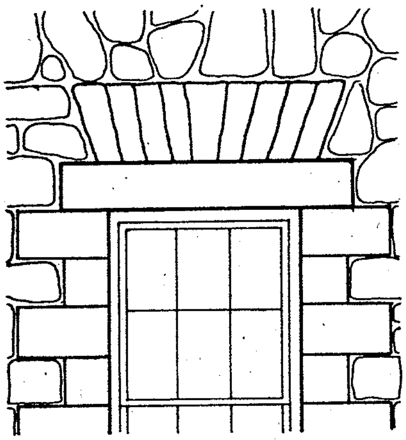
SIMPLE STONE LINTEL
IN ASHLAR WALL



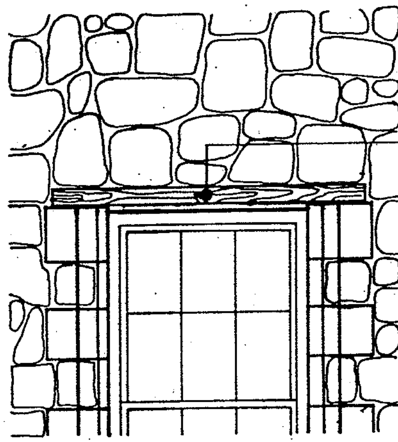
FLAT ARCH IN
RUSTICATED ASHLAR WALL



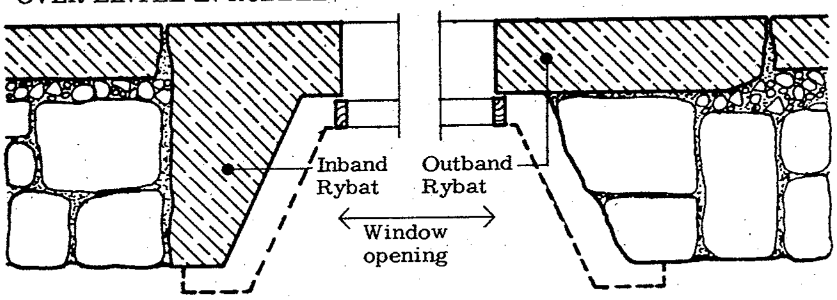
SEMI-CIRCULAR ARCH IN
RUSTICATED ASHLAR



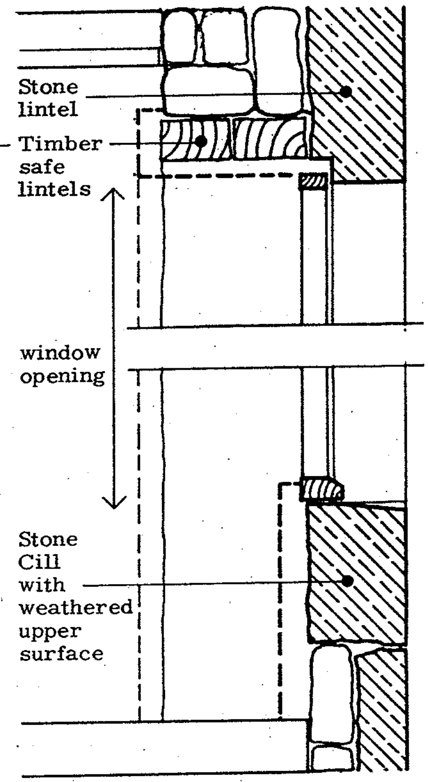
EXTERNAL RELIEVING ARCH
OVER LINTEL IN RUBBLE WALL



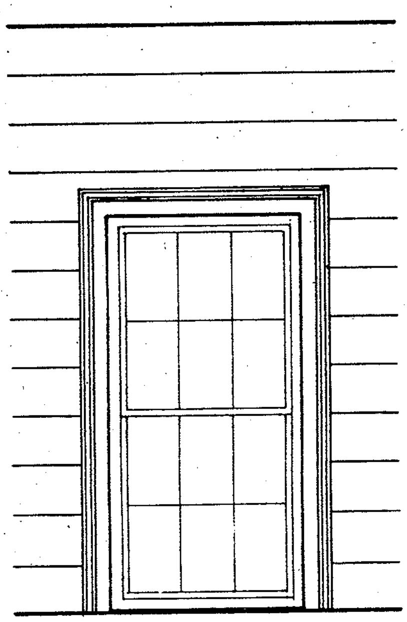
INTERNAL TIMBER SAFE
LINTELS OVER OPENING



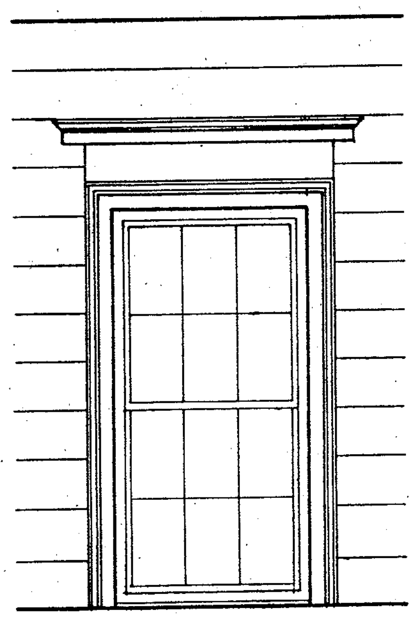
PLAN OF TYPICAL WINDOW OPENING



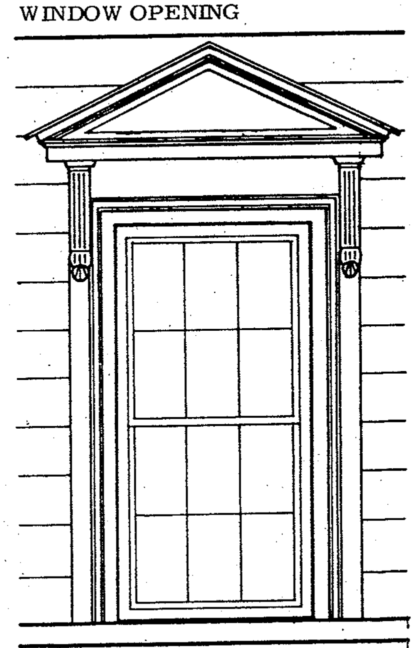
SECTION THROUGH
WINDOW OPENING



OPENING FRAMED BY
STONE ARCHITRAVES



OPENING FRAMED BY
STONE ARCHITRAVES,
FRIEZE & CORNICE



OPENING FRAMED BY
STONE ARCHITRAVES, FRIEZE
AND PEDIMENT WITH CONSOLES,

6. Wall Openings

The head of an opening is generally finished externally with a simple stone lintel or, more elaborately, with a flat or semi-circular arch. Rusticated ashlar flat arches, consisting of four voussoirs and a keystone, are common features over ground floor front elevation openings. The whole 'arch' is, in fact, usually formed of one large stone with false V-joints shaped on its face to conform with the adjacent masonry. Semi-circular arches, on the other hand, are constructed of individual stones and are commonly seen over street entrance doorways.

In rubble walls a stone, external 'relieving arch' is sometimes built above the main stone lintel. Internally, the rubble skin tends to support itself by natural arching over openings although heavy timber 'safe lintels' are invariably built into the wall in order to lend support.

Ideally, the jambs of window openings are bonded by using alternate headers (inband rybats) and stretchers (outband rybats). The inband rybats are rebated to receive the window frame and chamfered internally to conform to the splayed reveal which increases light transmission into the room.

Another method of forming window reveals is to use 'starts' or 'upstarts' on the external masonry skin. These tall, thin reveal stones are all of equal width and usually project slightly from the face of the wall. A 'start' generally refers to a stone which is not bonded into the jambs of the opening.

Stone architraves - often complete with surmounting entablature or pediment with consoles - are used to provide a decorative framing around window openings and, in particular, to enhance the grander fenestration of the First Floor or 'Piano Nobile'. The architraves are usually constructed of moulded 'starts'.

Apart from the use of semi-circular arches, (described above) the importance of street entrance doorways is sometimes stressed by flanking the opening with columns or pilasters which carry a pediment or entablature conforming to a classical order. Examples of these 'aediculated' door openings are discussed further in MM Sheet 2.02/1.

MM Sheet 2.02/1, Porticos.

Stone cills are in one length and bedded under the jambs by means of 'stools'. They either project beyond or remain flush with the face of the wall. A slight 'weathering' is usually worked on the upper surface of the cill.

BEDDING OF STONEWORK

Sandstone, like all sedimentary rocks, is of laminated construction and it is important that the direction of the bedding planes in a cut stone block be suited to the purpose and position of that block when used in building.

Ashlar should ideally be constructed of good quality freestone. The fine-grained homogeneity of this type of stone enables it to be cut easily in any direction and still retain a smooth surface and a sharp arris. However, most stones have more pronounced bedding planes, the direction of which can be determined by examining the Mica particles within the stone through a magnifying glass. The plane of these small flat glittering discs concurs with that of the laminations.

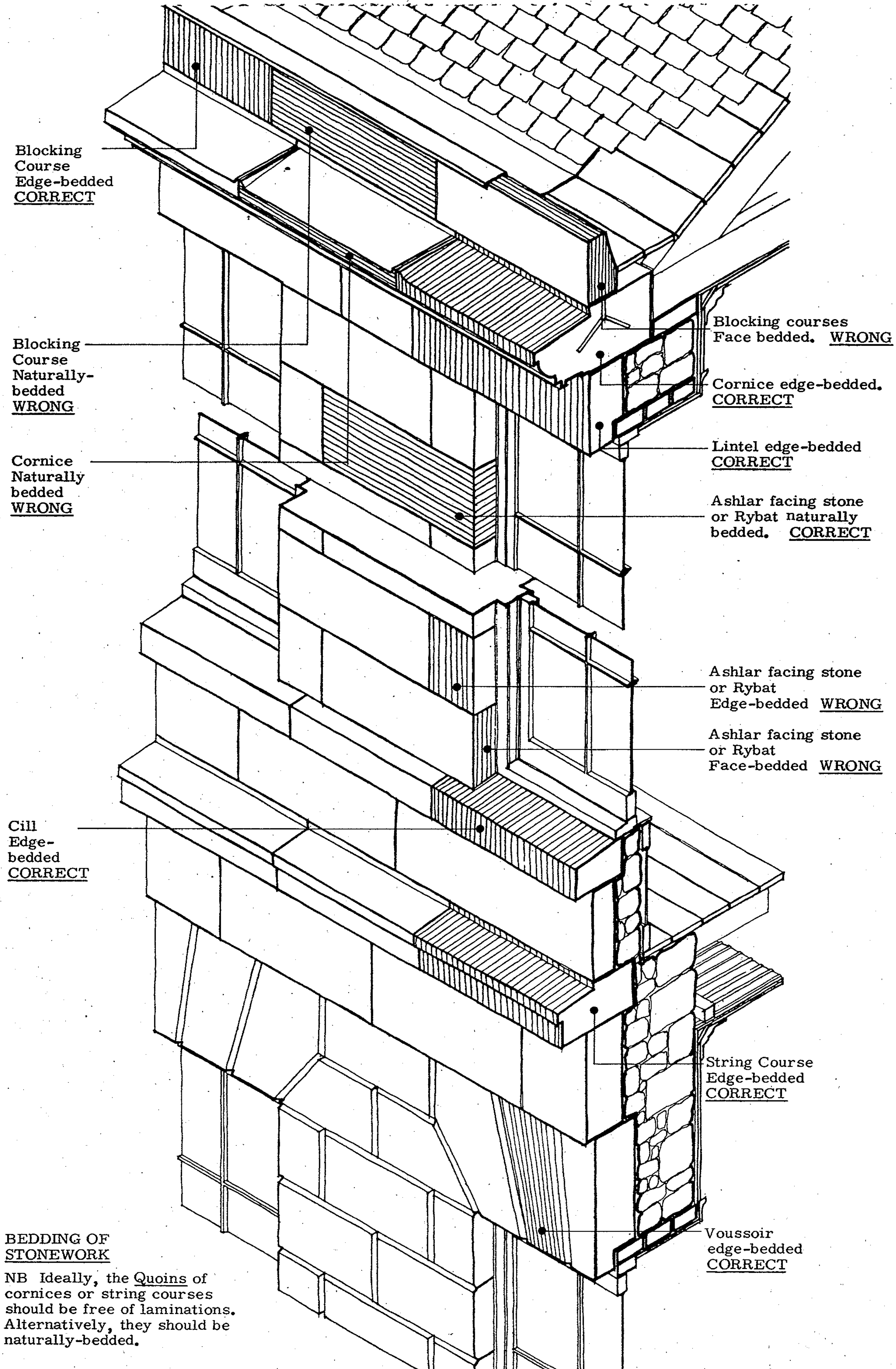
Repair and Maintenance of Houses. Melville & Gordon.

Stone can be 'naturally-bedded', 'edge-bedded', or 'face-bedded'.

1. Naturally-bedded stones are laid with their bedding planes horizontal (as in their natural state) and should always be used for normal ashlar walling. Because the bedding planes are laid at right angles to the downward pressures in the wall and are protected from the weather, the risk of surface disintegration is minimised.

2. Edge-bedded (or joint-bedded) stones are laid with their bedding planes vertical and perpendicular to any exposed surface. Edge-bedding is essential for string courses, cornices, cills etc. where natural bedding would tend to permit mouldings, throatings and projecting horizontal surfaces to be eroded rapidly. Arch stones should be carefully arranged so that the bedding planes are at right angles to the thrust (that is, parallel to the direction of the joints).

3. Face-bedded stones are laid with the bedding planes vertical and parallel to the face of the wall. This is often referred to as 'building on cant'. The surface layers of face-bedded stones will always tend to disintegrate, especially when exposed to the weather. This does not necessarily decrease the strength of the stone but, apart from appearing very unsightly, it can seriously affect the durability of the wall and lead to falling masonry.



BEDDING OF STONEWORK

NB Ideally, the Quoins of cornices or string courses should be free of laminations. Alternatively, they should be naturally-bedded.

from BUILDING STONE, . 1921 by William Lowndes

STONE CUTTING AND FINISHING

52. The art of stone cutting consists of making templates or patterns from which any stone can be cut and of cutting the stones to match these templates. These templates or patterns will be described later. Stones having carefully made joints and beds and which are accurately fitted into walls or other masonry construction, constitute what is known as **cut-stone work.** The stones themselves are called **cut stone.**

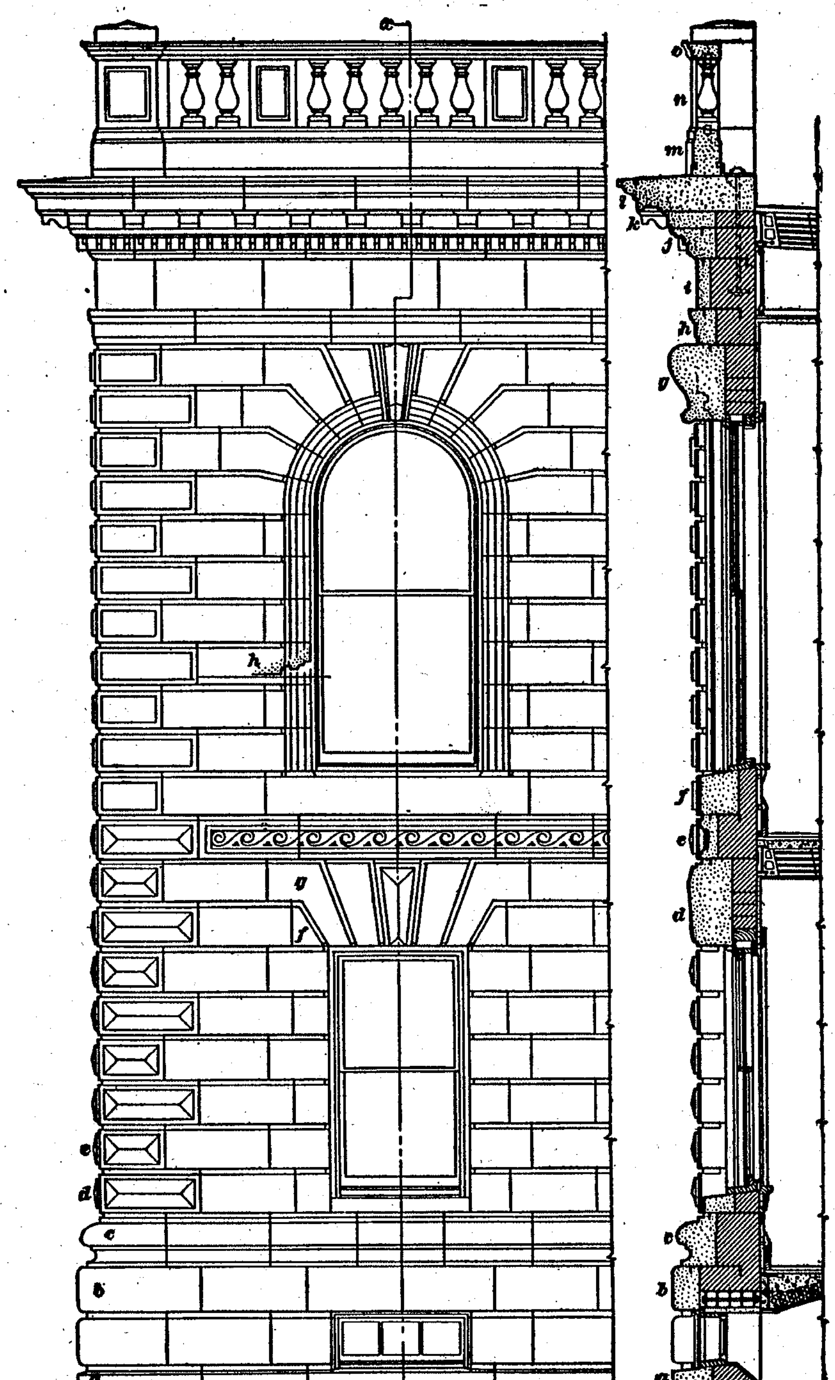
Cut-stone work is, as a rule, confined to the facing of walls which are backed by a cheaper material, and when the stone is so used it is referred to as **ashlar.** The methods used to produce such stonework are briefly described in the following pages.

DRAWINGS

53. Architect's Drawings.—In designing the façade, or front, of a building that is to be finished in ashlar, the architect generally lays out all the stones on his drawings with considerable care. The stones should have a pleasing shape, and be neither too large nor too small. The drawings of some details, such as moldings, cornices, and carvings, are usually made full size, so that the intention of the architect may be clearly understood, and as little as possible be left to the judgment of the stonecutter.

54. Fig. 5 (*a*) illustrates a portion of an architect's drawing of a building front finished in cut-stone work. The joints, as well as the moldings and ornamentation which are cut on the different stones *a*, *b*, *c*, *d*, and *e*, are all shown. The stone *f* is cut to receive the arch stone *g*. At *h* is shown a section through the stone jamb, indicating the form of the molding which is to be cut on the jambs of that window.

55. In (*b*) is shown a section through the front of the building on the line *x–x*, Fig. 5 (*a*). This line cuts the key-



(a) (b)

FIG. 5

stones of the arches in the first and second stories, and also the lintel over the basement window. A section through the basement sill is shown at *a*, and through the basement lintel at *b*. At *c* the section line cuts the string-course below the first-story window sills. A section through the keystone of the arch over the first-story window is shown at *d*, while *e* shows a section through the string-course below the second-story sill *f*. A section of the keystone of the arch over the second-story window is shown at *g*; and it will be noted that the outline of the jamb is shown in dotted lines at this point,

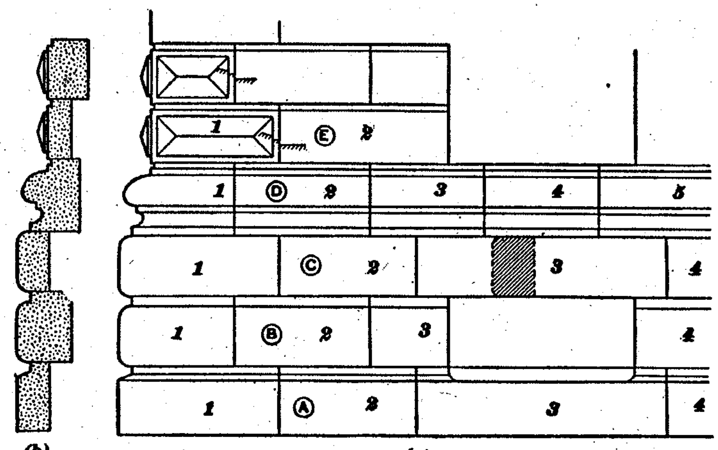


FIG. 6

as the circular jamb fits against the keystone. A section of the entablature is shown at *h*, *i*, *j*, *k*, and *l* and above this is a section through the balustrade at *m*, *n*, and *o*.

56. Stonecutter's Drawings.—From the architect's drawing, Fig. 5, the stonecutter makes a drawing, a portion of which is shown in Fig. 6, from which the stone is cut and also from which the stone is set in the building. In this drawing, in (*a*), each course is given a letter, beginning with *A* at the bottom course. The stones in each course are numbered from left to right, each being given a specific number as shown in the figure. This number, and the letter showing the course

are painted on the back of the stone for identification. When several of the stones are identical in shape and finish, the marking is sometimes repeated for each of them, so as to avoid the use of high numbers, and to avoid the necessity of looking for a stone having a particular number when there may be many others of the same size and finish available. A section through the cut-stone work is shown in (*b*).

57. Templets.—A *templet*, or *pattern*, is made for each different design of stone, and consists of a form cut out of sheet metal, cardboard, or heavy paper, showing the profile of any moldings or recesses in the stone. In Fig. 7 is illustrated a templet such as would be used for the stone course *A* in Fig. 6. This templet shows the profile of the exposed cut surface of all similar stones in this course. In laying out a stone, the top and bottom surfaces *a* and *b* are made parallel and straight, and the shape of the templet is marked on the end of the stone. The stone is then put into the planing machine, which will be described later, and is cut to this profile throughout its entire length. A similar templet is shown in Fig. 8 for the stone in the course *D* in Fig. 6. Special templets are made for the stones with special shapes, such as the keystone in the second-story window. The shapes or profiles of all these special stones are obtained from the full-size drawings, which are made in the architect's office and sent to the stonecutter for his guidance.

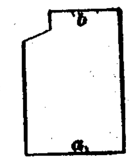


FIG. 7

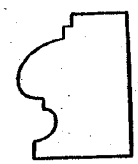


FIG. 8

CUTTING STONE BY MACHINE

58. Most of the cutting of stonework for buildings is done in stone yards by machines. These machines are arranged generally in one of two different ways. In one case they are arranged in a rough circle around a central derrick, as shown in Fig. 9. In this figure the arrangement of the yard is roughly indicated, with the various machines located at *a*, *b*, *c*, *d*, and *e*, and piles of stone at *f*, *g*, etc. All of these are readily reached

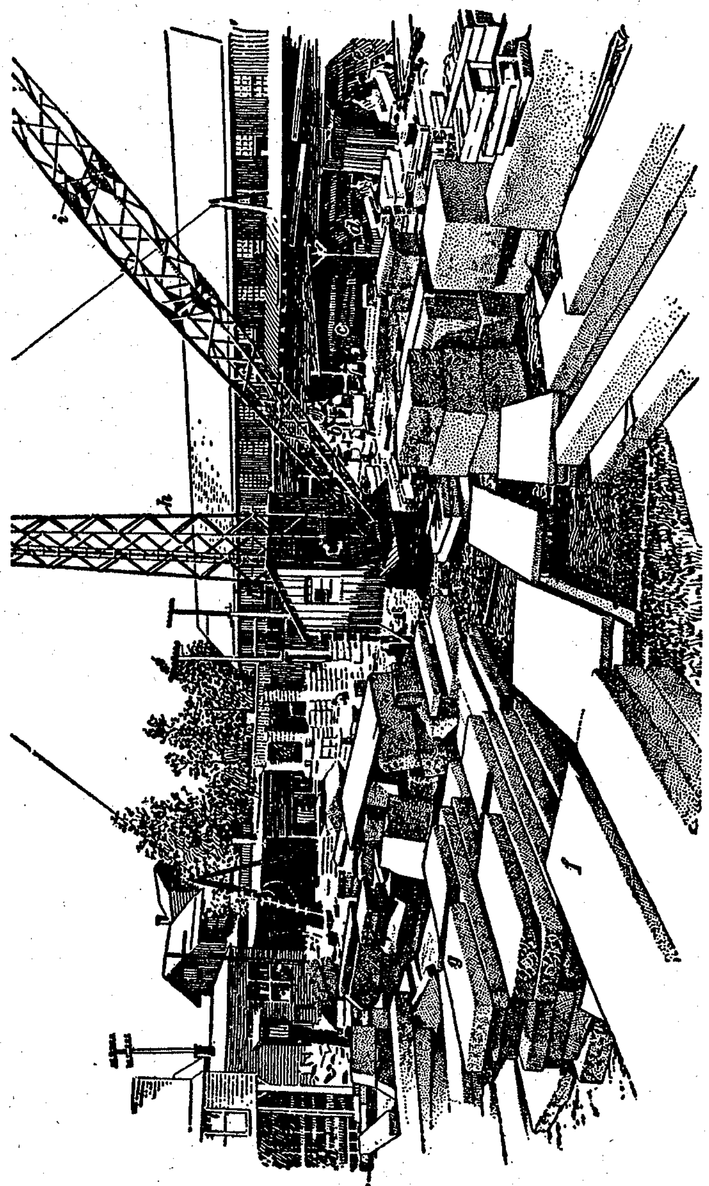


Fig. 9

by the derrick *h*, which, by means of the boom *i*, lifts the stone from the piles at *f* and *g* and deposits it on the beds of the various machines and also removes the finished work from the machines and deposits it on the wagons to be shipped away, or in other positions where further cutting may, if necessary, be done upon it. Another type of stone yard or shed is that in which there is a traveling crane which moves back and forth along the length of the yard or building. In this case, the machines may be placed at any convenient point in the building and still be properly served by the crane. The principal machines used in stone cutting are *saws, planers, lathes, grinders, polishers,* and *pneumatic tools.*

SAWS

59. Gang Saws.—The gang saw illustrated in Fig. 10 is one generally used to cut rough stone into small portions and is used particularly on hard stone like granite. These machines

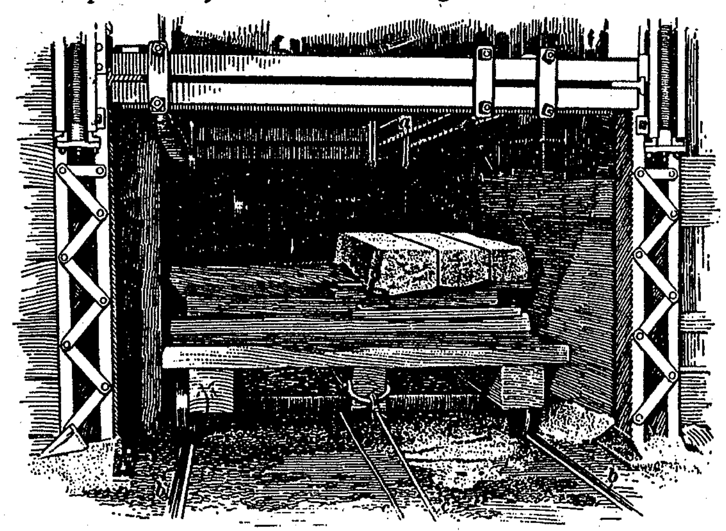


Fig. 10

consist of saws *a*, which are long bands of steel with their edges cut to form rectangular teeth. These saws are drawn back and forth through the stone in the same manner as a ish color. These diamonds take the place of the teeth of the ordinary saw and, when the saw is revolved rapidly, the stone is cut with great facility and speed. Such a saw is shown at *a* in Fig. 12. Four slabs of stone *b*, on a truck *c*, are being cut at one operation. The saw is arranged to travel across the frame *d* of the machine, and the truck may be locked by the brake *e* to the rails *f* at any desired point.

In another style of machine, Fig. 13, the stone *a* is fastened to a bed *b*, which travels past the saws *c*. The saws may be moved to any point on the supporting member *d*, which may

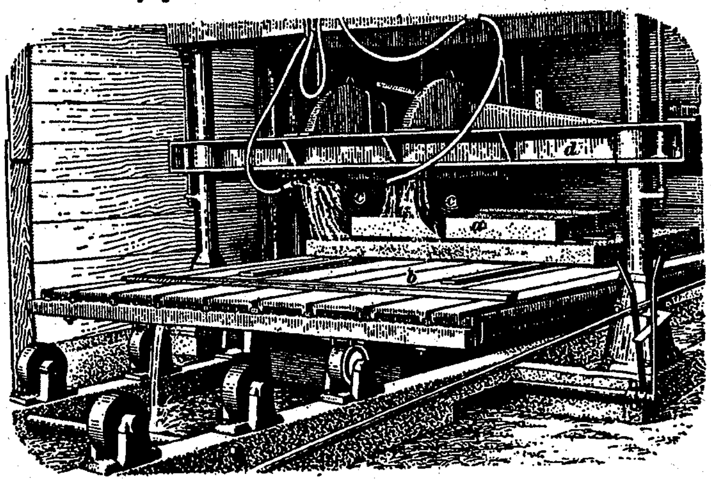


FIG. 13

be raised or lowered as desired. Streams of water directed against the sides and edges of the saws keep them cool.

61. Carborundum Saws.—Carborundum saws are circular saws of steel which have teeth made of carborundum instead of being fitted with diamonds. These saws are very effective and are used in the same manner as diamond saws.

62. Band Saws.—Band saws are similar to the band saws which are used for woodwork, the cutting edge running downwards in a vertical direction. The cutting is done by the aid of sand or carborundum, and water, that are introduced into the cut during the sawing process.

32.

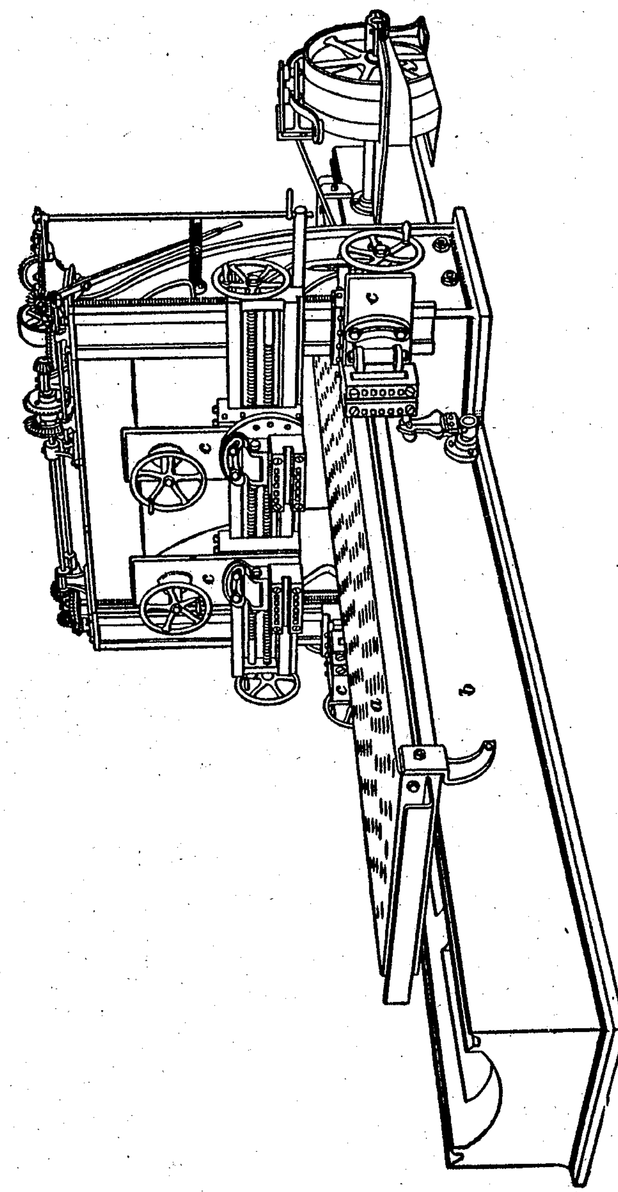


FIG. 14

345B—3

PLANERS

63. A **planer** consists essentially of a heavy sliding bed of steel *a*, in Fig. 14, on a foundation *b*. To the bed *a*, the stone to be planed or molded is securely fastened by blocks which are inserted in holes in the plate. Tools suitable for cutting the molding required are firmly held in the heads *c*, and the plate *a* is set in motion, forcing the stone against the edges of these tools, thus scraping off the surfaces of the stone to the desired shape. These tools can be moved up or down or sidewise as may be desired. Planers are used generally where

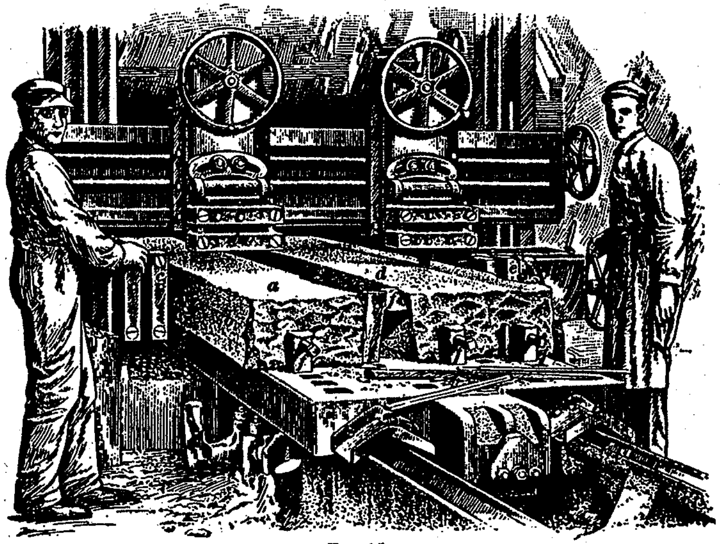


FIG. 15

the moldings or surfaces are perfectly straight, but where moldings are to be run on a curved surface the work may be done on a somewhat similar machine arranged to do that kind of work. In Fig. 15 two pieces of stone are being planed at one time, on a machine similar to that shown in Fig. 14. The stone *a* has the top surface finished and the side *b* is being finished by the tool *c*. The stone *d* has the tool *e* dressing the side, while a similar tool is finishing the face or top. The stones are held in place by the blocking at *f*.

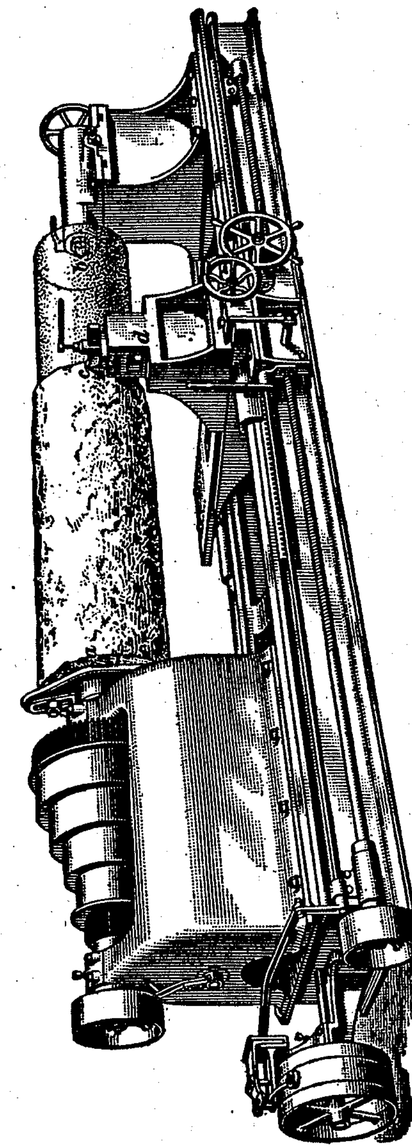


FIG. 16

LATHES

64. One style of **lathe,** shown in Fig. 16, may be used for turning columns, balusters, and similar work. The stone, held between the centers of the headstock *a* and the tailstock *b*, and revolved against the cutting tool *c*, inserted in the toolpost *d*, is pared down to the required size. Lathes are made in various sizes, the one shown being capable of turning colums 66 inches in diameter and 24 feet long. Attachments are provided for fluting when desired.

POLISHERS

65. One form of **polisher,** or **polishing machine,** is illustrated in Fig. 17. This machine consists of a pedestal *a* and a horizontal arm *b*. On the lower extremity of this arm is a disk *c*, which is fitted with carborundum blocks. This disk is revolved rapidly by means of belts worked on the pulleys *d*. The belts are omitted from this figure for the sake of clearness. The rapidly revolving disk is applied to the surface of the stone *e*, as shown, and can be moved to any part of the stone by means of the handle *f*, thus polishing the entire surface of the stone.

Another type of polishing machine consists of a fixed bed similar to that used in a planer, to which the stone to be pol-

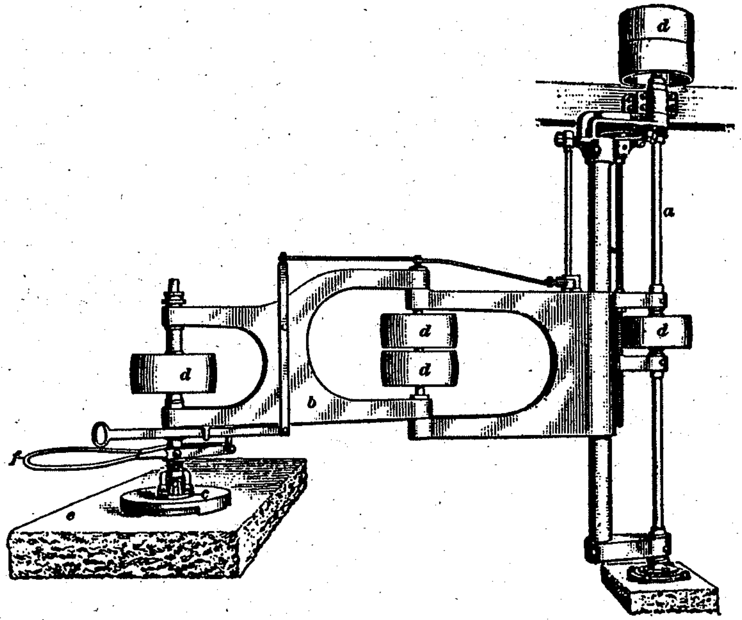


FIG. 17

ished is secured by blocks and wedges. Circular disks having carborundum surfaces are revolved rapidly over the surface of the stone, producing the desired polished or rubbed effect. Machines of this type are used principally for polishing granite and marble.

PNEUMATIC TOOLS

66. Pneumatic tools, shown in Figs. 18, 19, 20, and 21, are used to a large extent in modern stone yards, especially for cutting granite, marble, and bluestone. Pneumatic tools, as

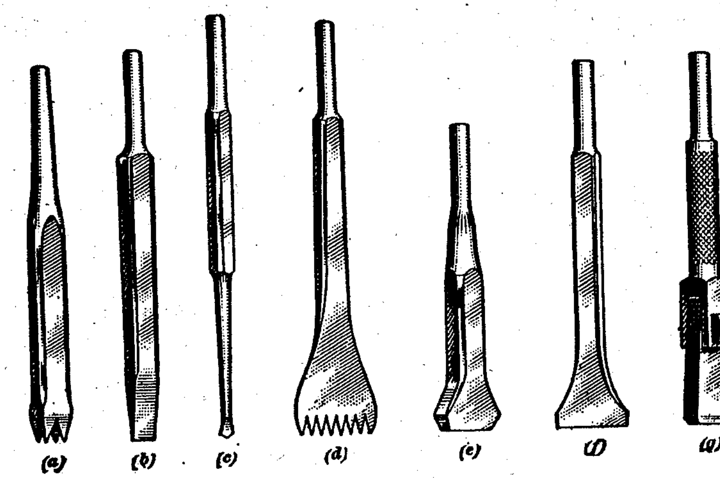


FIG. 18

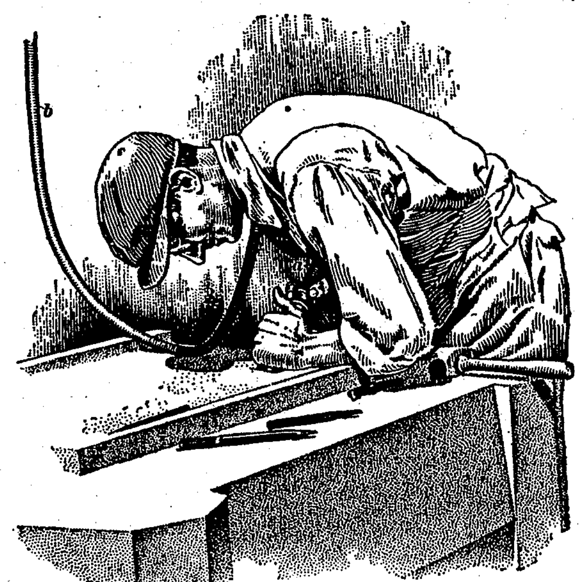


FIG. 19

shown in Figs. 19 and 20, consist of steel cylinders *a*, with movable pistons or hammers worked by air pressure, connected with air-compressing engines by means of a stout hose *b*, through which the compressed air is conveyed. Tools of various types are shown in Fig. 18, and these tools can be placed in the opening in the cylinder and driven by a succession of extremely rapid blows which cut the stone much more rapidly than it can possibly be done by hand.

In (*a*), Fig. 18, is shown a *tooth chisel;* in (*b*), a *plain chisel;* in (*c*), a *carver's drill;* in (*d*), a *marble tooth chisel;* in (*e*),

FIG. 20

a *double-bladed chisel;* in (*f*), a *cleaning-up chisel;* and in (*g*), a *bush chisel.* The general method of using these tools may be seen in Figs. 19 and 20.

67. A heavier type of pneumatic tool or stone dresser mounted on a pedestal is shown in Fig. 21. The tool holder *a* may be moved to any part of the hinged arm *b*, which may be raised or lowered on the pedestal *c*. This form of mounting takes the weight of the device from the operator and allows him to give his whole attention to directing the edge of the cutting chisel *d* to any part of the stone to be dressed.

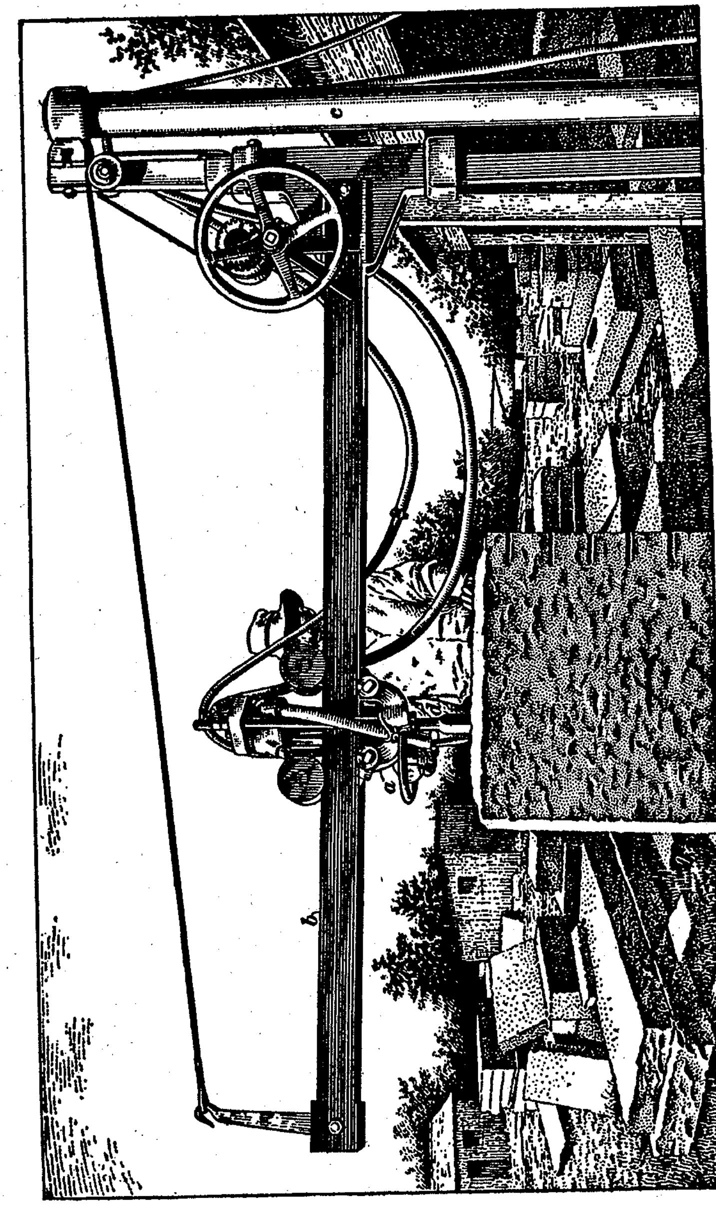


FIG. 21

68. Pneumatic tools, while suitable for granite, marble, and bluestone, are not considered satisfactory for use on very soft stones, as the action of these tools is rather severe for these stones. Pneumatic tools are used sometimes, however, for roughing out the softer stones.

CUTTING STONE BY HAND

69. As far as possible, the stone is cut by machinery. There are, however, cases where it is necessary to do considerable cutting by hand. Round or curved work in limestone is generally cut with hand tools. Hand tools are also used in fitting stones as they are about to be placed in the building after having been delivered from the stone yard. On a good-sized building one or two stone masons are kept busy constantly, cutting and fitting stones for the masons to set when they are erecting the stonework on the building. This is necessary, particularly on a building having a steel framework, where the backs of the stones must be cut out to fit in against the steelwork. A brief description of some of the hand tools that are used for cutting stones at the building and in the stone yard is given in the following pages.

HAND CUTTING TOOLS

70. Hammers and Mallets.—Masons' hammers are made of steel and are used for breaking and roughly shaping the stones as they come from the quarry. The **double-faced hammer** is shown in Fig. 22 (*a*) and weighs from 20 to 30 pounds. The **face hammer,** shown in (*b*), is a lighter tool than the double-faced hammer, weighing from 12 to 16 pounds, and is used for the same purposes as the double-faced hammer when less weight is required. It has one blunt and one cutting end, the latter being used for dressing the stones roughly preparatory to using the finer tools.

The **stone pick** shown in (*c*) is used for dressing the softer stones coarsely; its length is from 15 to 24 inches, and the thickness at the eye is about 2 inches.

36

The **peen hammer** shown in (*d*) is about 10 inches long, and has two cutting edges about 4 inches in length; it is used for making *drafts,* or margin lines, around the edges of stones, and for dressing the faces.

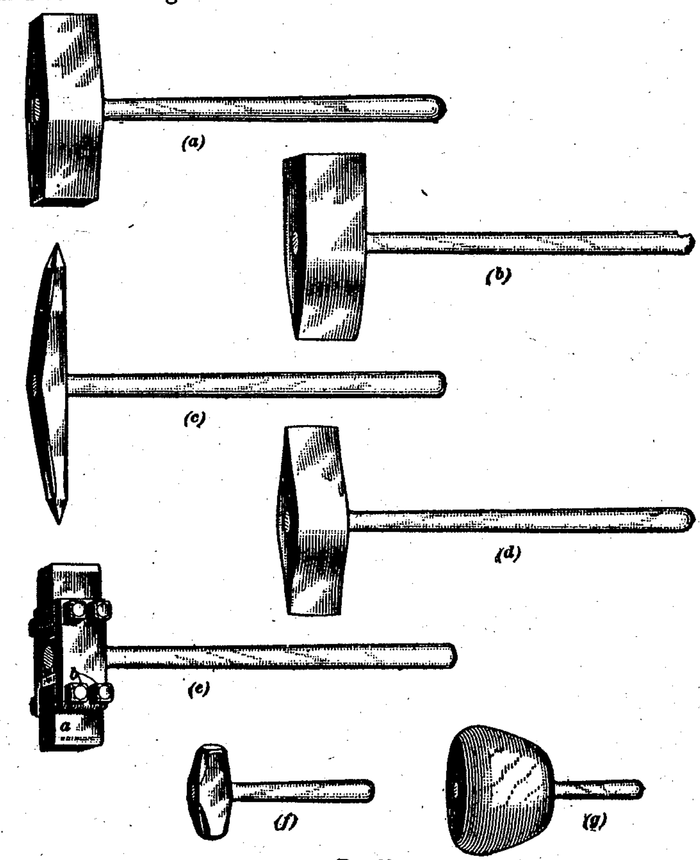


FIG. 22

The **bush hammer** shown in (*e*) is made of from four to ten thin blades of steel *a*, which are ground to an edge and held together by bolts *b*, so as to form a single tool. This hammer is used for finishing granite or hard limestone. The number of blades to the inch determines the fineness of the cut, which is specified as four-, six-, eight-, or ten-cut.

In (f) is shown a **mason's hand hammer,** which weighs from 2 to 5 pounds and has a short handle. It is used with

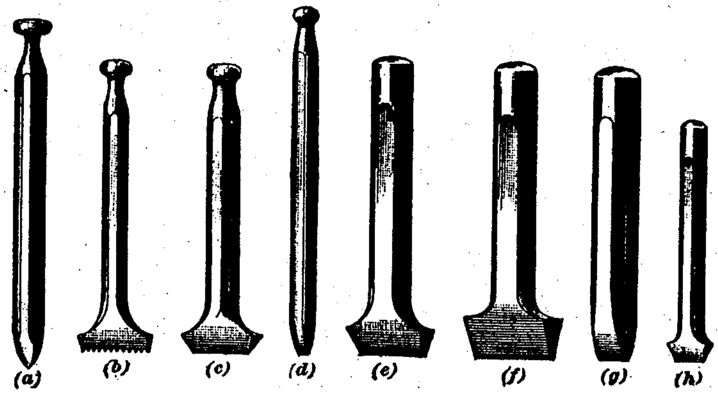


FIG. 23

various tools for drilling holes, and for pointing, pitching, and chiseling the harder stones.

The **mallet** shown in (g) is used in cutting soft stones. It is made of hickory wood, the head being about 7 or 8 inches in diameter and 5 or 6 inches in height.

71. In Fig. 23 (a) is shown a **point,** which is a tool made of round or octagonal steel, 8 to 12 inches long, with one end pointed. The point is used in chipping off the rough faces of the stone and reducing them to approximately plane surfaces.

The **tooth chisel** shown in (b) is used on marble and sandstone to reduce the surfaces that have been partially leveled by the point.

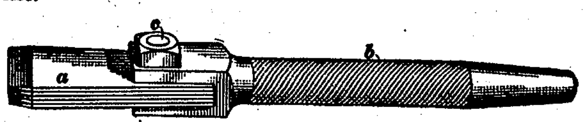


FIG. 24

In (c) is shown a **pitching tool,** made of steel, ¾ to 1¼ inches in thickness. It is used to form straight edges on stones.

In (d) is shown an ordinary **chisel.** Chisels are used in smoothing off the rough surfaces of stone and are made with cutting edges that are from ¾ to 1½ inches in width.

The tools shown in (a), (b), (c), and (d) have *mallet heads* and are driven by means of the mallet. Other forms of chisels with plain heads are shown in (e), (f), (g), and (h) and are driven with steel hammers.

The **hand bush chisel** shown in Fig. 24 has a number of blades a held in the shank b by means of the bolt c, and is used in places that cannot be reached with the bush hammer.

FINISH OF STONEWORK

72. In the architect's drawings the stones and the joints between them are shown. The stonecutter makes a detail of each stone and cuts it to fit exactly against the adjacent stones. The finish of the exposed surfaces of the stones is specified by the architect. A few of the more common finishes that are specified will be described in the following pages.

73. Rock-Faced Work.—In Fig. 25 is shown **rock-faced,** or **pitch-faced,** work, and the method of using the pitching chisel. The face of the stone is left rough, just as it comes from the quarry, and the joints, or edges, are pitched off to a line, as shown at a. As very little work is required for this finish, rock-faced dressing is cheaper than any other kind, especially when granite, bluestone, or hard limestone is used. Care must be taken, however, that no tool marks show on the finished surface of the stone. An example of rock-faced bluestone is shown in Fig. 26. The methods of laying up this work are treated in another Section.

FIG. 25

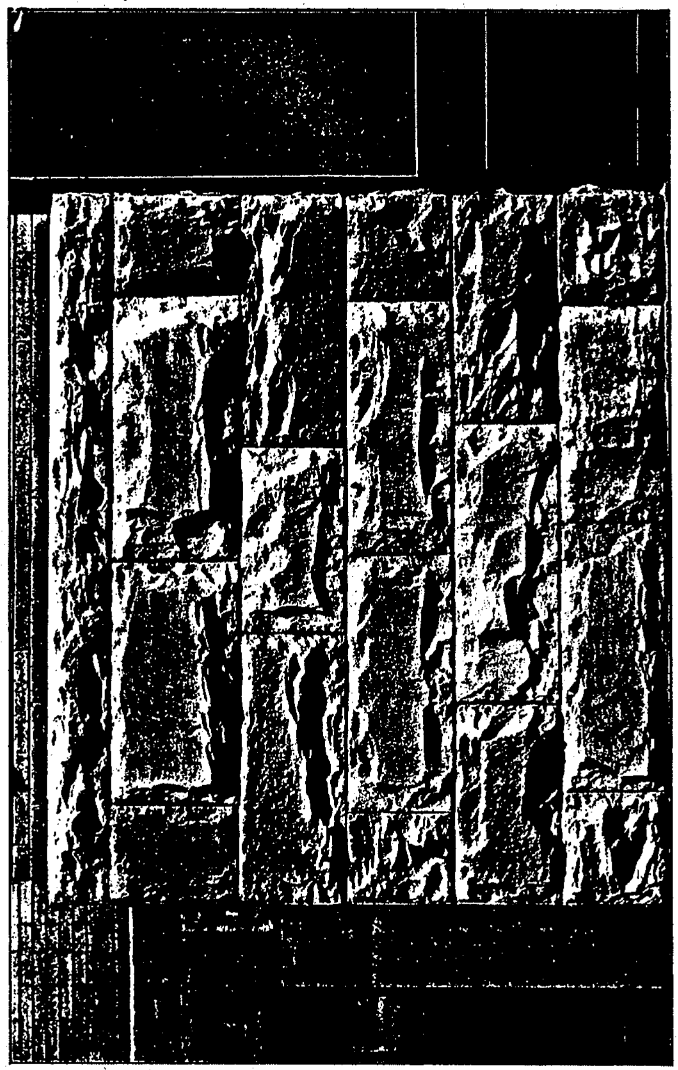


Fig. 26

74. Pointed Work.—An example of **pointed work** is shown in Fig. 27. This effect is produced by taking off the

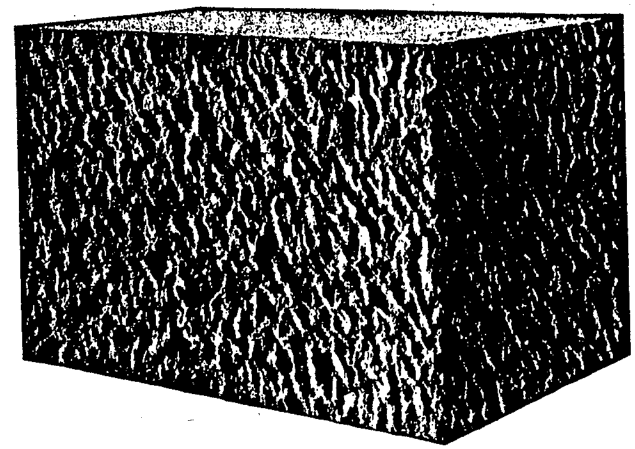


Fig. 27

projections of the stone by the use of the point. After the stone is worked over a few times it will present a rough sur-

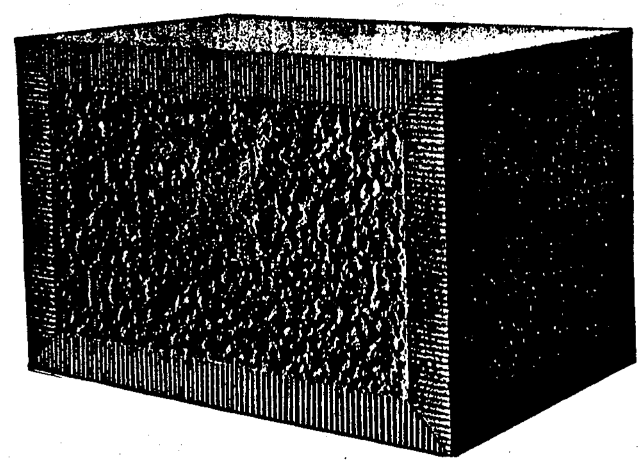


Fig. 28

face, as shown in this figure. This work is called **rough-pointed.** If, however, the work is gone over several times more with the point, a finer effect is produced, such as shown in Fig. 28, which is known as **fine-pointed work.**

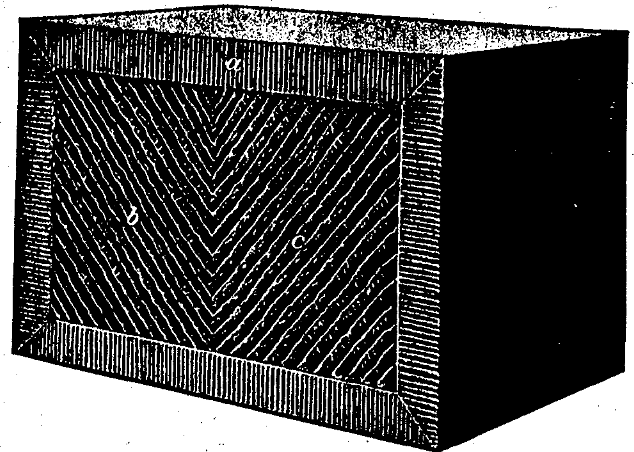


FIG. 29

75. Margins.—Building stones are sometimes faced an inch or more from their edges as shown in Fig. 28, and at *a*

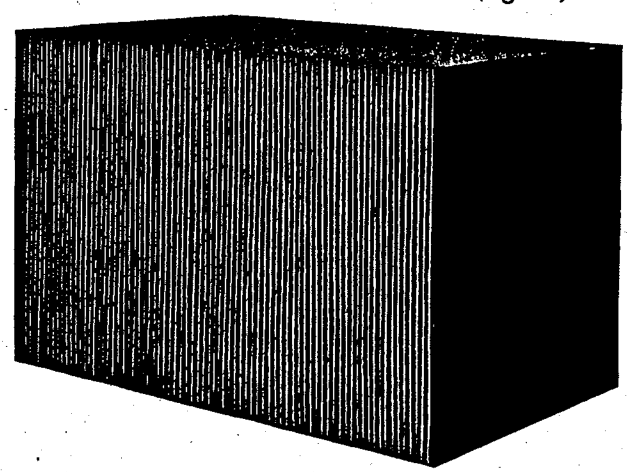


FIG. 30

in Fig. 29. This facing is known as a **margin, or draft.** On soft stone, this margin is cut with a chisel, but on very hard

stone, such as granite, it is cut usually with an ax, or peen hammer, in which case the surface would be plainer than the chiseled work and without the well-defined parallel channeling.

76. Broached Work.—Fig. 29 illustrates what is sometimes called broached work. In this kind of work the stone is dressed with a point, so as to leave continuous grooves over the surface. At *a* is shown the margin, and at *b* and *c* the broached center, which is cut in opposite directions in order to illustrate right- and left-hand broaching, respectively.

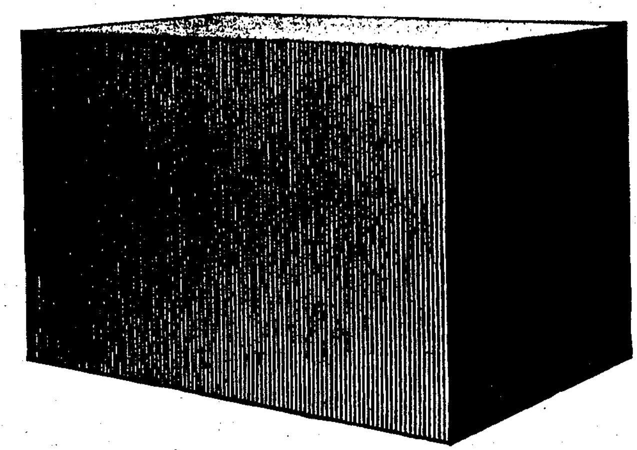


FIG. 31

77. Tooled, or Drove, Work.—Tooled, or drove, work is illustrated in Figs. 30 and 31. This class of work is generally done by machine and shows a regular and even appearance, as in Fig. 31. It may also be done by hand, in which case it has a somewhat more irregular and possibly more pleasing effect, as shown in Fig. 30. Drove work is described as six-cut, eight-cut, and ten-cut, according to the number of grooves to the inch.

78. Rubbed Work.—Sandstones and most of the limestones are often finished by rubbing their surfaces until they are perfectly smooth. By continuing the rubbing long enough, granite and marble can be given beautiful polishes. Rubbed work is finished either by hand, using a piece of soft stone with water and sand, or by a machine which performs the same operation. If the rubbing is done soon after the stones are sawed into slabs and are still soft, it is cheaply and easily performed, as the sawing makes the face of the stone comparatively smooth. This kind of finish is shown in the plain surfaces around the carved panels in Figs. 39, 40, and 41.

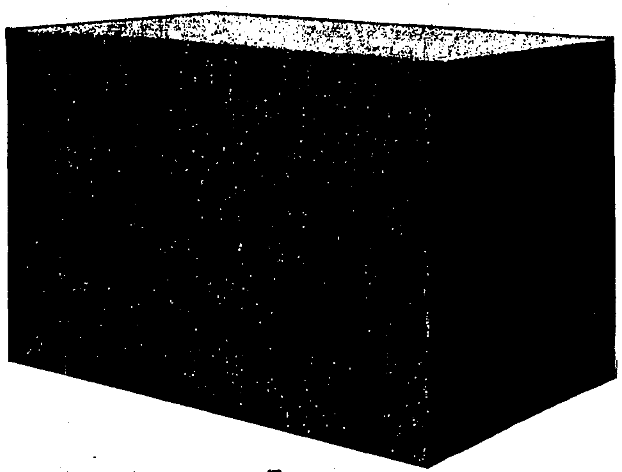


FIG. 32

79. Bush-Hammered Work.—A stone finished by a bush hammer or pneumatic bush chisel, which is generally used on granite and hard limestone, is shown in Fig. 32. The stone is first dressed to a fairly smooth surface and then finished with the bush hammer. The degree of fineness in the finish is determined by the thinness of blades in the hammer, the usual number being eight or ten to the inch.

80. Vermiculated Work.—In Fig. 33 is shown a stone having a somewhat elaborate finish, which is known as vermiculated, from its worm-eaten appearance. Stones so cut are used principally as quoins and in base courses. Owing to the cost, this dressing is not often used in the United States, except for very expensive work.

81. Rusticated Work.—Two examples of rusticated work are illustrated in Figs. 34 and 35, the former showing

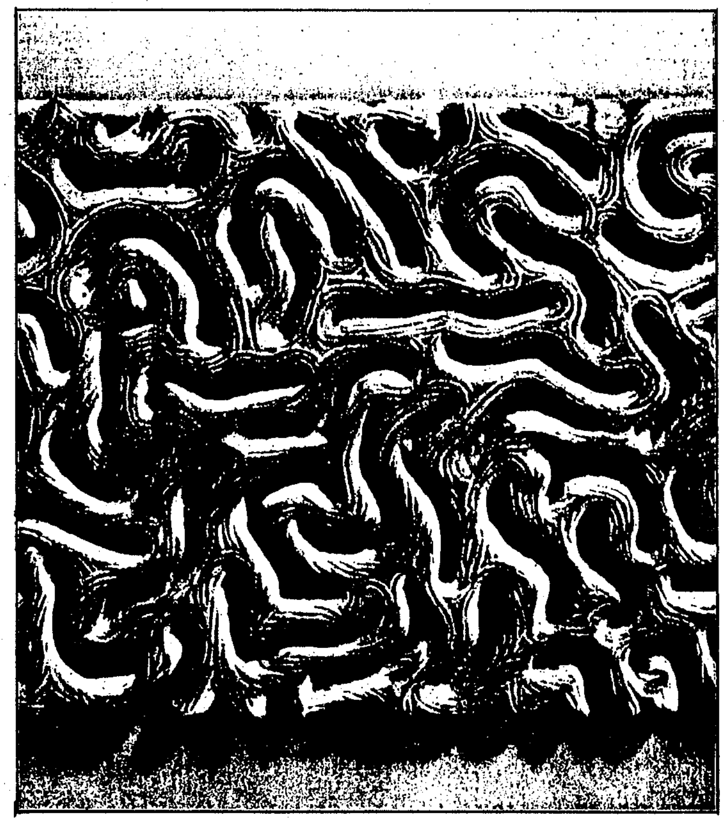


FIG. 33

the stones with sharp edges and the latter the stones with rounded edges. The joint should always be at the upper edge of the rustication as shown at *a* in each illustration, as it is better protected from the weather when in this position. If the joint were placed at the lower edge of the rustication, rainwater would lie on the lower horizontal surface and be liable to work its way back into the joint. The projection above the joint throws a heavy shadow at this point and strongly emphasizes the courses. The use of rustication is further illustrated in Fig. 5.

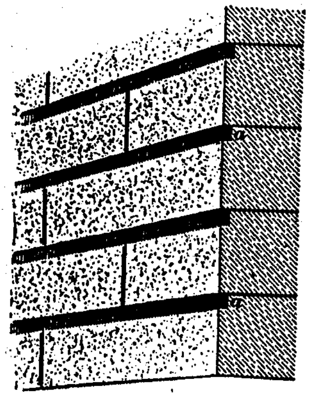


FIG. 34

The height of the rustication should bear some simple proportion to the total height from joint to joint, and should not ordinarily be less than one-sixth of that height. The depth of the rustication should be about two-thirds of its height if the edges are square, as in Fig. 34; if the edges are rounded, as in Fig. 35, the depth should be equal to the height. The rustication is sometimes obtained by **V** joints, wherein the edges of the stone are chamfered or splayed. Rusticated masonry is sometimes laid with close vertical joints, as in Fig. 34, but is more frequently laid with the vertical, as well as the horizontal, joints rusticated, as in Fig. 35. The latter method gives the better effect when the stones are of good length.

Rusticated work is used in massive buildings, usually for the first story, forming a heavy base treatment strong in shadowed joints, on which is placed the lighter and more ornate upper stories, where the joints are close or, if rusticated, very much smaller than those below. The surface of rusticated stonework is usually dressed in such a way as to give a rough appearance; this may be done either in rough-pointed, fine-pointed, or vermiculated work, as shown in Figs. 27, 28, and 33, respectively. These surfaces form a

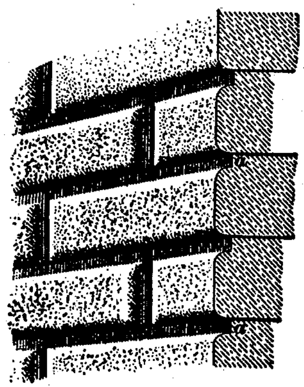


FIG. 35

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pleasing contrast with the plainer surfaces of the stones above. Good examples of rusticated masonry are to be seen in the Italian palaces of the Renaissance period.

CARVED WORK

82. The preparation or cutting of stone surfaces has been taken up, and thus far rough rock faces and dressed faces, such as fine- and rough-pointed, bush-hammered, vermiculated, etc., have been considered. The final step in the elaboration of stone is **carved work.** This requires more skill than common surface finishing, and in fact is an art requiring the skill of the sculptor. A close relation exists between stone dressing, as already described, and stone carving, to be described. The same tools are used, but, in general, less attention is paid in carving to securing an even surface than to the artistic effect of each line or surface.

83. The object of stone carving is to embellish the building, to bring out the color and the attractiveness of the stone, and to give the building individuality from the nature of the decoration. Carving, therefore, as distinct from stone dressing, is employed for individual stones or masses of stones.

84. Carving was originally applied to that ornament which was cut by hand. As machines now do the work, or assist in the work which was formerly done by hand, the former distinction will no longer apply. In general, therefore, the term carving is applied to the individual decoration by cutting of various stones.

85. Carving may be done on the solid block, on surfaces dressed by the methods described, or on moldings which have been cut by the machines mentioned. The carving may be done in the shop, on the site of the building, or on the façade after the exterior of the building is otherwise complete.

86. Work which can be carved in small pieces, so as to be readily handled and set without danger of breakage, is usually done in the shop, where tools and material provide every facility in the way of cutting and handling.

87. Some stones are carved on the ground near the building when there is sufficient space and the nature of the building will permit the setting of the stone as the work progresses. This method of cutting overcomes the risk incident to transportation.

88. Elaborate carving on large blocks, such as groups of figures or statuary, sustains too great a risk of breakage to be done by either of the methods mentioned. In such cases, the rough block of stone, or the stone roughly dressed to the approximate shape of the finished ornamentation, is set in place, and the carving done from a scaffold after the danger of damage is past. This refers particularly to large carvings with considerable projection near the base of high buildings, where quantities of materials will be hoisted past them, or where materials are apt to fall on the finished work and damage it beyond repair.

89. The softer stones, such as the limestones and marbles, being more easily worked, are more generally used for carving, as the expense is much less than when the granites and hard sandstones are employed. Care must be taken also to employ for carving, stones having a uniform texture and hardness throughout, as well as those which will stand the weather well. Great quantities of Indiana limestone are used for carving in the United States.

90. The scale and the minuteness with which carving should be executed depends on its height from the point or points from which it will be seen. Work that will be close to the eye of the observer should be carved out in great detail and fineness if the texture of the stone will permit it, while work at some height from the eye to be effective should be bold and coarse in treatment. The latter point is often overlooked, and minute carving, beautiful in itself when viewed at close range, loses its effectiveness when placed at such a height that much of its detail is lost.

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91. In general, the same tools already described for stone dressing are used for stone carving. For some stones the tools may be adapted to particular uses, and, especially for marble, smaller and finer-edged tools are required for more delicate carvings.

92. Carving is usually done from full-size drawings prepared in the architect's office, or from models prepared for the approval of the architect or owner of the building.

93. Instead of making templets of all the work, the stonecutter often resorts to expedients which will shorten the labor of preparing the stone for cutting. When the detail is a simple one and the drawing has been made full size by the architect, the detail is sometimes drawn on the end or face of the stone. An instance of this character is shown in Fig. 36. The pencil lines *a*, *b*, and *c* may be seen where they have been drawn ready for the stonecutter to cut the internal angle. The line *d* is used in laying out the profile of the molding *a*. A similar stone, cut to the lines marked, and ready to set in the building, is shown in Fig. 37.

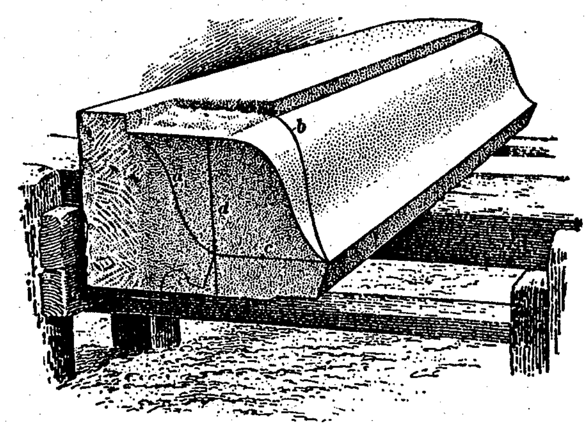

Fig. 36

94. Where the detail is a little more elaborate, the lines of the architect's full-size drawing are sometimes pricked through the paper with a fine needle at close intervals. The drawing is then laid on the stone and fine charcoal or graphite is sprinkled over the drawing. Sufficient of the material sifts through the holes to locate the lines so that they can be drawn in pencil on the stone. Care in laying out the design is essential to a satisfactory carving.

95. Models in clay are frequently prepared, in order that the architect, the owner, and others may judge of the appearance of the finished work. Plaster casts are made from these models and are used by the stonecutter in place of drawings. The plaster cast is used in preference to the model, as it is

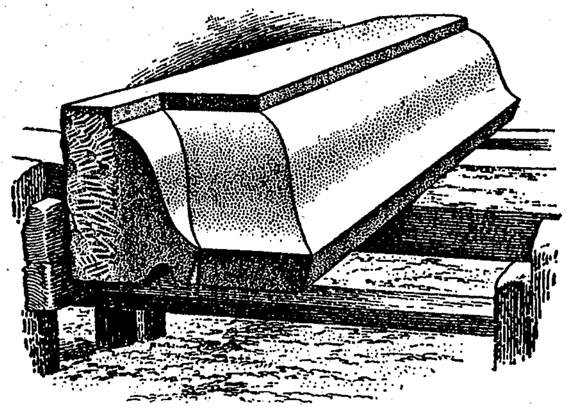

FIG. 37

lighter in weight, and if damaged can be replaced. The expert carver can successfully reproduce the plaster model in stone. Definite rules cannot be laid down for measuring or laying out this class of work, the eye of the carver being trusted usually to reproduce faithfully the lines of the model from which he works.

96. The ornament is roughly blocked out by means of the point (*a*), Fig. 23, followed by chisels or other tools that will bring the work to the proper outline with the least number of cuts. A variety of surface and background textures are possible by the use of the various tools already mentioned.

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97. A large portion of the cornice of a building is sometimes made in one piece, as in Fig. 38, which shows a workman cutting or carving by hand the sides of the dentils in the course *a*, which cannot be made on the planer. The finishing of this course is all the handwork required on this cornice.

98. When carved work is set in the building before the completion of the building, it should be boxed or covered with boards to protect it from any possible damage.

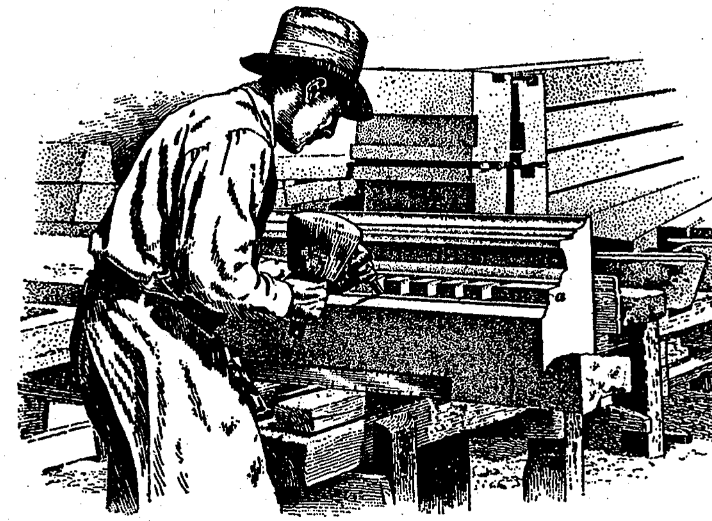

FIG. 38

99. Besides figure work, carved ornament is utilized for the decoration of plain or molded band-courses, capitals and bases of columns, pilasters, balustrades, friezes, panels, etc. Conventional or naturalistic plant and animal forms, as well as geometrical forms, are used as motifs for these ornaments. Figs. 39, 40, and 41 illustrate specimens of work executed on the City Hall of Philadelphia, Pennsylvania.

100. In Fig. 39 is shown an example of naturalistic carving in *alto*- or high-relief, and in *bas*-, or low-relief. The forms used are plant and bird life. The two plants represented are

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MASONRY

(PART 1)

FINISHINGS AND WALLING

* * *

TECHNICAL TERMS

2. **Bond Stones.**—All stone walls require **bond stones,** or stones placed at intervals to run through from front to back of the wall. In the case of very thick walls they run from front to two-thirds of the thickness, so as to tie in the various courses of stones across the thickness of the wall and bind the whole together. The courses underneath should be brought to an exact level to receive the stones; otherwise, the weight above may cause them to crack or become displaced. In the case of piers, the stones should be cut to the full size of the pier whenever possible.

* * *

STONE DRESSINGS

5. **Definition.**—The term **stone dressings** is used to describe the dressed and cut stonework used in a building for ornamental purposes. It includes any such work as quoins, jamb stones, lintels and sills, corbels, string courses, cornices, moulded copings, columns and entablature, tracery, etc., but does not include ashlar. The stones for such work should be of good quality and have the beds closely dressed and the ends square and properly matched. The faces may be pitched off, but all weatherings,

soffits, etc., should be cut or rubbed. When a brick building has stone dressings, great care should be taken to have the dressings of the proper depth, agreeing with the depth of a certain number of brick courses, so that it will not be necessary to split the courses of brick below or above, for such a procedure would spoil the appearance of the building.

6. **Quoins.**—The corner stones of a wall are known as **quoins,** and should bond with the work on both faces of the wall. They are often dressed differently from the other stones in order to make them more prominent. Quoin stones should always be equal in size to the largest stone used in the wall; otherwise, the effect of strength and solidity that they are intended to produce will be lost. Sometimes the quoins in a rubble-stone wall are built of brick. Fig. 1 shows an example of stone quoins bonded on both faces to ashlar walls, *a* being projecting plain quoins, and *b* quoins emphasized by margins and self-facing.

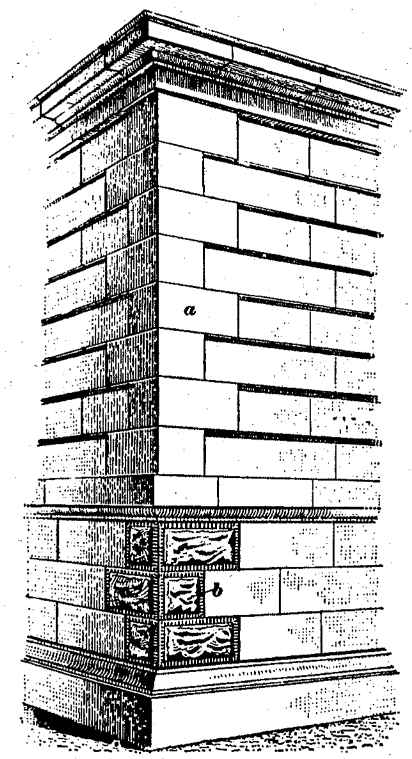

Fig. 1

7. **Jamb Stones.**—The stones in the sides of a door or window opening are called **jamb stones,** and the stones forming the inside angle are sometimes termed **scuntions.** Fig. 2 represents cut stone jambs in a rubble wall: *a* shows the jamb stones bonding into the wall transversely; *b*, those bonding longitudinally; *c*, the stone window sill; *d*, the rubble wall; and *e*, the

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scantions. Occasionally, when stone piers or pilasters are built

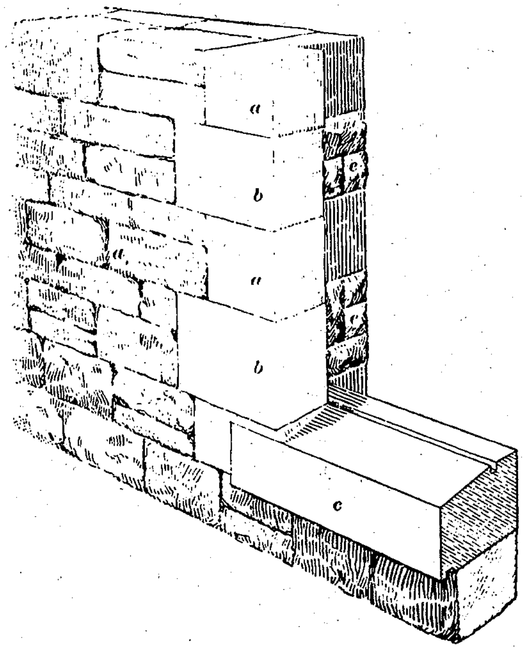

Fig. 2

on the outside of a building, the windows are recessed so that

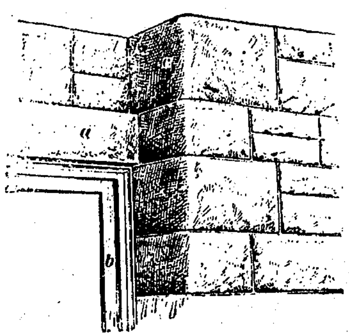

Fig. 3

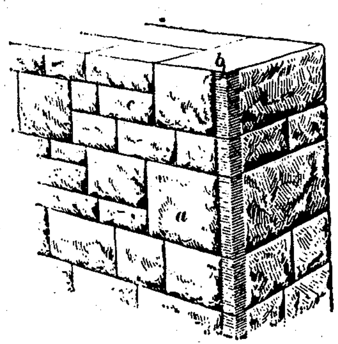

Fig. 4

the projection of the sills and lintels will not be so noticeable. This is shown in Fig. 3, in which *a* shows the lintel; *b*, the sash;

and *c*, one of the jamb stones. Jambs and quoins are often finished with a draught, or angle line, especially when the softer stones are used. Fig. 4 shows this method of finishing: *a* indicates the quoin or jamb stone, as the case may be; *b*, the angle draught; and *c*, the squared and snecked rubble wall.

LINTELS

8. A **lintel** is a stone fixed horizontally across an opening to carry the wall or other weight above. It may consist of a single stone, which may or may not require that some of its load be removed by means of relieving arches or steel; or it may consist of several stones joined in some manner and used in conjunction with some method of relieving the direct weight on it.

As a lintel must resist bending stress, it should be a strong, tough stone having an ample cross-section. The ends of the lintels should not be built into the walls more than is necessary to give sufficient bearing; 6 to 9 inches at each end is the usual allowance. There should be a little play allowed at each end, so that the lintels can yield slightly without cracking if the walls on either side settle unevenly.

9. Strength of Lintels.—A lintel acts as a beam, hence the ordinary beam formulæ will apply. For uniformly loaded beams, the breaking load is found as follows:

Rule.—*Multiply twice the breadth, in inches, by the square of the depth, in inches, and also by the proper constant. Divide the product by the span, in feet; the quotient will be the breaking weight for a uniformly loaded beam.*

Expressed as a formula, this rule is:

$$\frac{2\,b\,d^2\,A}{L} = W$$

in which b = breadth, in inches;
d = depth, in inches;
L = span, in feet;
A = constant;
W = breaking load, in pounds.

The value of the constant A is for granite, 100; for limestone, 83; for marble, 103; for slate, 275; and for sandstone, 60.

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If the weight is concentrated at the centre, the breaking load is $\frac{1}{2}W$ instead of W.

When the weight on a lintel consists of a dead load that is not liable to shocks, such as masonry, one-sixth of the breaking load may be taken as safe. If, however, the lintel is subject to live loads of any kind, not more than one-tenth of the breaking load should be taken. In such cases it is better to avoid the use of stone lintels, unless reinforced by angles or beams.

EXAMPLE.—Find the safe uniform load of a sandstone lintel 10 inches broad, 24 inches high, 7 feet long between supports, and uniformly loaded.

SOLUTION.—Substituting in the formula,

$$W = \frac{2 \times 10 \times 24^2 \times 60}{7} = 98,743 \text{ lb.}$$

Taking one-sixth of this, gives 16,457 lb. as the safe uniformly distributed load. Ans.

10. When the opening is wide or the load heavy, the lintel must be increased in depth. This may produce a clumsy appearance, to avoid which it is desirable to strengthen the stone or relieve it of some of its load. A simple method of doing this is by using an arch, which may be of almost any style. Fig. 5 (*a*) shows the elevation and (*b*) the section of a relieving arch, *b* going through the wall and taking most of the weight off the head *a*.

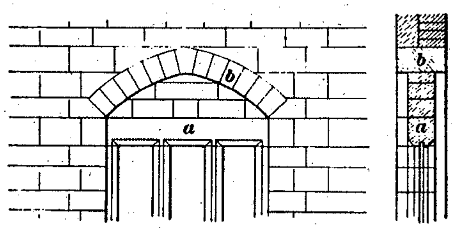


FIG. 5

Fig. 6 shows a method often used. A rough ring arch *b* is built inside the wall and takes some of the weight from the lintel *a* without disturbing the facing. The section through the rough arch is shown in (*b*); and its outline is shown dotted in the elevation (*a*). Lintels of various materials are largely used when the head of a window comes near the floor above.

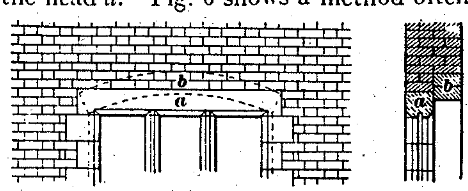


FIG. 6

11. Relieving Lintels.—Often when a long lintel is used over an opening, the stonework above the lintel is arranged as shown

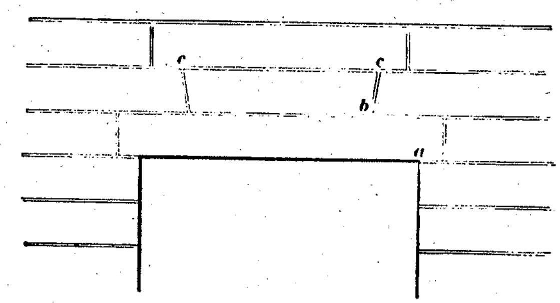


FIG. 7

in Fig. 7, in which *a* is the lintel and *b* the **relieving lintel,** or stone above it cut with two radiating joints, as at *c*, *c*. In this way, some of the load is taken off the lintel and transferred to the wall on both sides of the opening. When a lintel extends through

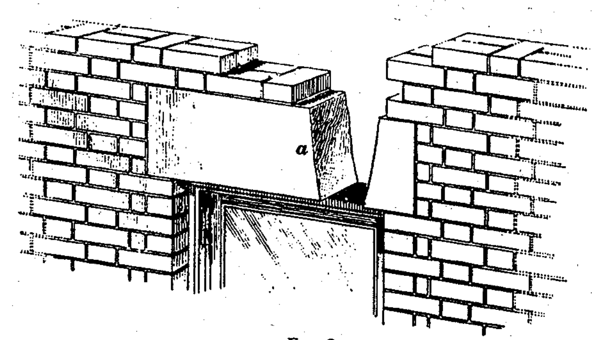


FIG. 8

the wall and is not supported by angles or beams, the strength may be increased, if the stone is stratified, by cutting it in such a manner that the layers will set on edge, as shown at *a*, Fig. 8. This procedure, however, may cause the face of the lintel to flake off if the layers of stratification are thin and not securely joined together.

12. Repairing Lintels.—If a stone lintel should crack and it is not easy to replace it, the lintel may be strengthened by the use of iron beams or angles. When the lintel is of moderate length, it is sufficient to use a piece of angle iron, as shown in Fig. 9, in which *a* is the stone lintel; *b*, the angle iron, which should have its longer side vertical; *c*, a wooden beam to which the interior woodwork is nailed; *d*, the brick wall; and *e*, the window reveal.

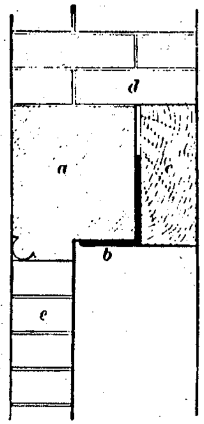


Fig. 9

13. Steel Supports.—When the width of the opening is considerable, stone lintels should be supported on **I** beams. If only the weight of the lintel and wall is to be carried, a single **I** beam may be used, as shown in Fig. 10, in which *a* represents the stone lintel; *b*, the **I** beam; *c*, the beam to which the wood finishings are attached; *d*, the reveal; and *e*, the brick wall. When, in addition to the walls, the floor joists over openings must be carried, it is best to use two **I** beams, as shown in Fig. 11, in which *a* is the stone lintel; *b*, *b*, the **I** beams, held together by bolts and separators; *c*, an iron plate on which the wall rests; *d*, a joist; *e*, the window reveal; and *f*, the brick wall.

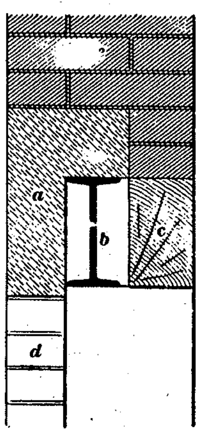


Fig. 10

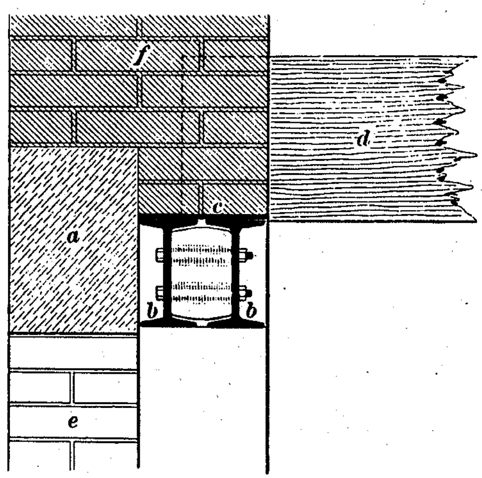


Fig. 11

14. When it can be avoided, the best plan is not to support the weight of a wall on both stone and steel or wooden beams, as the deflection of each material is different, making it practically impossible for each to carry its proper share of the load. The weight should preferably be borne by the steel beams alone. The best method of using steel to relieve the weight on a stone lintel is to form a lintel of coke-breeze concrete with a rolled-steel joist embedded in it. This has the further advantages over the method just given in that the steel is protected against fire; besides, joists and joinery may be fixed direct to the lintel, while it gives a face inside the wall in the right plane for plastering. Fig. 12 shows a section of this arrangement, *a* being the stone lintel; *b*, the concrete lintel; *c*, the rolled-steel joist; and *d*, the floor joist.

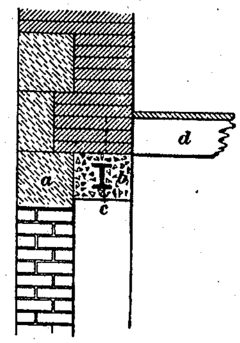


Fig. 12

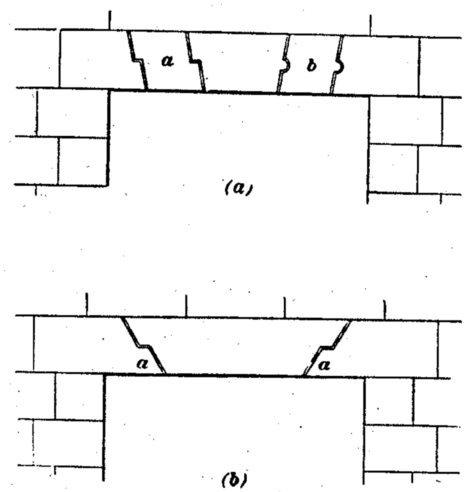


Fig. 13

15. Built-Up Lintels.—As it is sometimes necessary to use a stone lintel 10 or 12 feet long, which is difficult to obtain in a single piece, the lintel may be made in sections. At least three stones should be used, and the joints should be cut as shown at *a, a*, Fig. 13 (*b*), for the stones are then self-supporting. The end pieces must be built into the wall for a considerable length, so as to act as cantilevers supporting the middle section. If such long lintels are used, however, it is better to carry them on **I** beams, as shown in Fig. 10. Another method of arranging the stones in a built-up lintel is shown in Fig. 13 (*a*). The joints shown at *a* are known as *rabbeted;* those at *b*, as *joggled*. It is well, in stonework, to try to place all openings directly above one another.

SILLS

16. In masonry, **sill** is the name given to the stones that form the bottom of the window and door openings in stone or brick walls. They are generally dressed plain or moulded, usually with a projection, but sometimes flush with the wall.

17. Lug sills have flat ends, or *lugs*, built into the wall. These lugs should not enter the walls more than 6 inches and should be bedded on mortar only at the ends. If a sill is bedded solid and settlement occurs, it will probably be fractured at the jamb line, as the pier or side walls are apt to settle more than the wall under the opening. The joints under the sills should be filled when the finished walls are cleaned down.

18. Slip sills are made just the width of the opening, and are not built into the walls, being put in place after the frame is set. Slip sills are cheaper, but do not look as well as lug sills; besides, there are exposed vertical joints at the ends into which water will penetrate. Any settlement of the masonry is not liable to break a slip sill, and hence they are often used in the lower parts of heavy buildings.

19. All sills should have a bevel, or *weathering*, of about 1 inch to the foot, extending to the back of the reveal, as shown in Fig. 14. They sometimes have a straight bevelled surface the full length of the sill, the brickwork being made to fit the stone. This, however, is not good practice, as such construction permits water, running down the jamb, to enter the joint between

the brick and the stone; the sloping upper face also forms an insecure bearing for the wall resting on it. In Fig. 14 is shown the proper method of cutting the surfaces: *a* indicates the flat end of the lug sill, carrying the brickwork reveal *c*; *b* shows the bevel, or weathering; and *d*, the drip or throating so placed

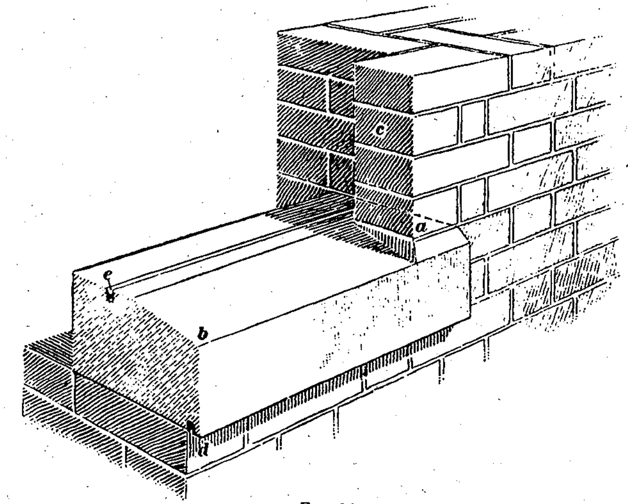


FIG. 14

that water will drip off the face of the sill and not run down the face of the wall; *e* shows the groove which should be made to allow the metal water bar to be inserted between the stone and wood sills, so that water may not drive up between the joint.

STRINGS AND CORNICES

20. Continuous projecting bands of stone on a building, usually moulded, are termed **string courses;** a similar band round an arch is known as a **label,** or **hood, mould.** In both these cases, the projection from the face of the wall is comparatively slight. Certain moulded bands, considerably larger than strings, from their position and projection are termed **cornices.**

21. Weathering and Throating.—The tops of all string courses and cornices should have an outward and downward slope from the walls, as shown at b, Fig. 15 (a), which is known as the **weathering**. If the top is level, rain will collect and, in time, cause the disintegration of the mortar in the adjacent joints and penetrate the wall. On the under side of the cornices, etc., **throatings**, or **drips**, a, should be made to prevent rain-water flowing down and discolouring the face of the wall. In certain districts, the local by-laws insist that water from a cornice shall not drip over the public way. When this is the case, a gutter must be formed at the back of the cornice by grooving the stone as shown at a, Fig. 15 (b), and weathering the cornice backwards to this groove. When cornices are finished in this manner they should be covered with sheet lead to prevent rain-water soaking into the stone and decaying it. The lead should be very carefully dressed over the stone and fitted into the groove a to form a gutter from which pipes can be taken at intervals along the cornice, and be connected to the main rain-water pipes of the building. The lead should be dressed over the front member of the cornice as shown at b, Fig. 15 (b), and should be turned up against the wall and tucked into a groove in the same manner as shown at c, so that any water running down the face of the wall

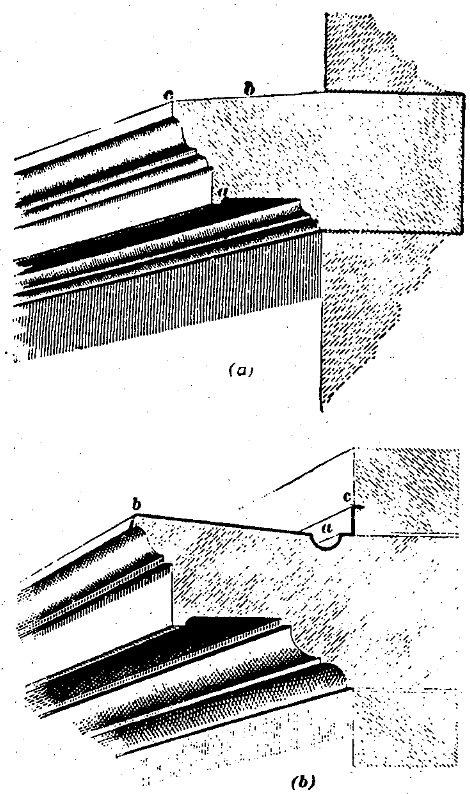


FIG. 15

will find its way into the groove at a rather than between the lead and the stone. Great care must be taken, when designing cornices or other projecting members, that they have sufficient bed on the wall, that is, that they project far enough into the wall to counterbalance the tendency to tip over due to the weight of the part projecting. Of course, the weight of the wall over that part of the cornice stone resting on the wall will help considerably to tie it down, but it must not be forgotten that the weight of the portion projecting beyond the face of the wall is very considerable.

22. **Stone Corbels.**—When it is desired to project a portion of the upper part of a wall over the lower, or to provide the extra

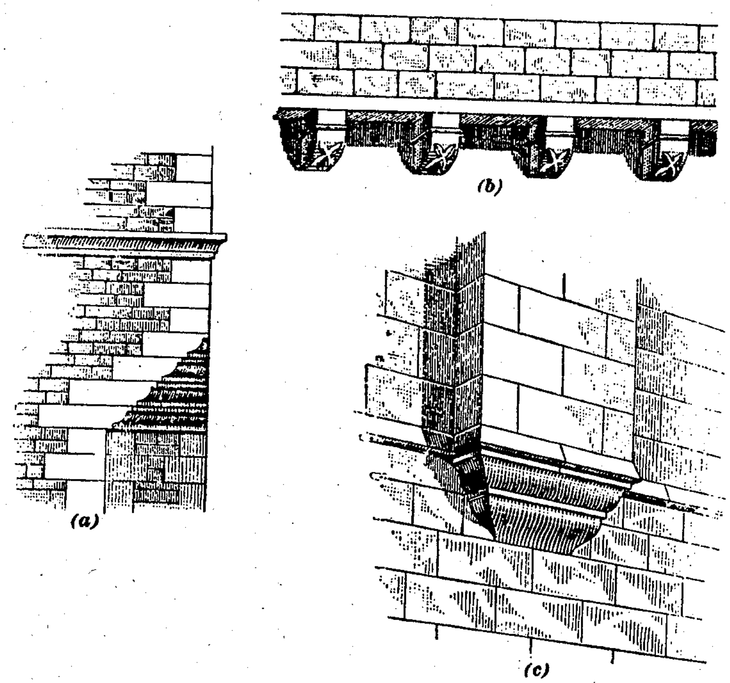


FIG. 16

thickness necessary to form the fireplaces and flues of an upper story, **corbel stones** are used. These are generally of the same size and strength, but vary in form. Corbels are also used under beams and for carrying wall plates supporting joists and floors, and are a prominent feature in certain styles of architecture. When visible from below, they are generally moulded, though in some cases carved. Fig. 16 (*a*) illustrates the method of corbelling the corner of a building; Fig. 16 (*b*), the method of supporting a projecting course with small corbels, known as a *corbel table;* Fig. 16 (*c*), the moulded corbelling for a projecting chimney.

COPING

23. Coping Stones.—To prevent the rain washing out the joints between the bricks or stone, parapet and similar walls are capped with a wide stone called a **coping.** This coping should be of non-absorbent stone, about 3 or 4 inches wider than the wall. The upper surface should be weathered, as shown at *a*, Fig. 17 (*a*), and should have a throating or drip on the under side, as at *b*. Horizontal coping stones are often clamped together at their ends to prevent their becoming displaced. Other types of coping stones are shown in Fig. 17 (*b*) and (*c*). In (*b*) is shown one weathered only one way; this will need a drip on one side only, while in (*c*) is shown a coping stone with curved weathering.

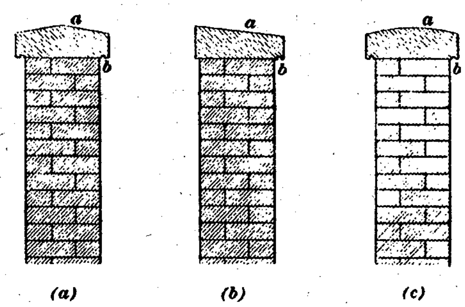


FIG. 17

24. Gable copings should be anchored either by bond stones or by long iron ties. A form of coping that is considerably used is shown in Fig. 18, in which *a* is the coping; *c*, the corbel or shoulder; and *b*, the bottom stone, sometimes known as the *skewback*, which should always be well bonded into the wall.

In some cases, the coping is cut in steps, so that each stone will have a horizontal bearing on the wall. This method is

objectionable, however, on account of the increased number of joints. It is well to have long pieces of coping, so as to reduce the number of joints: a common length is 6 feet. A short piece cut as shown at *d*, Fig. 18, and known as a kneeler, should be inserted at intervals to securely bond the coping to the wall.

Gable copings do not necessarily have to be weathered on top, but they should project on both sides of the wall and have a throating at each side, so as to shed the rainwater.

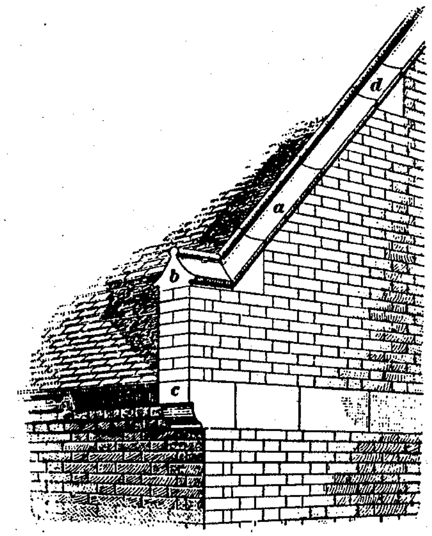


FIG. 18

25. Apex Stone.—Fig. 19 shows an **apex stone** for a gable on a roof of heavy construction. The apex is cut out of a single stone, and is made with a flat bed so as to rest solidly on the end wall. The two faces are grooved to receive the coping stones as shown at *a*, in the illustration. The apex is often secured to the wall by means of iron ties, which are placed inside the building.

COLUMNS AND ENTABLATURES

26. Columns.—A **column** is a long upright body which supports some superincumbent weight. It is constructed either of one stone, in which case it is termed a *monolith*, or of a series of stones fixed one above the other and of some regular shape in section. It is often circular, but just as often hexagonal, octagonal, or of any other geometrical section. It is often used as a method of ornamentation only. In Fig. 20 (*a*) is shown a column *a*, *b*, *c* standing on a pedestal *d*. A column is divided into three parts as shown, where a is the base, b the shaft and c the capital.

When a column is to be formed of several pieces, the stones composing the different parts should be very carefully cut, having the abutting surfaces between the capital, base, and shaft perfectly plane and perpendicular to the axis of the column, in order that the pressure may be evenly distributed over the entire surface of the joints. For the joints, nothing but cement mortar should be used, which should not be allowed to come within $\frac{3}{4}$ inch of the edge of the joint, in order to prevent the edges of the stones from spalling. **Capitals** and **bases** should, if size permits, be in one piece. If the capital is to be carved, it should be done, if possible, after it is fixed in place. A column may be either *detached* or *attached*, according to the position it occupies. It is said to be **detached** when it is entirely free throughout its whole section, as shown in Fig. 21 (a), where a is the column standing free or detached from the wall b. When a column is partly bonded into a wall, it is said to be **attached**, an instance of which is shown in Fig. 21 (b), where a is the column bonded into or attached to the wall b.

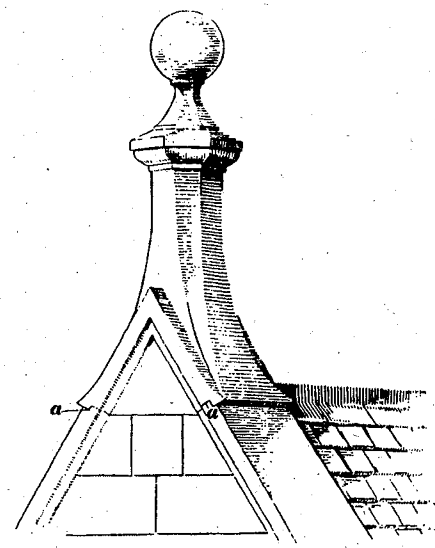


FIG. 19

27. Entablatures.—An **entablature** in classic architecture referred to the architrave, frieze, and cornice carried over a column or series of columns, as shown in Fig. 20 (a) and (b), where e is the architrave, f the frieze, and g the cornice. Above the entablature is shown a **balustrade** h, which can be designed

in many styles; the one shown has moulded balusters i spaced at regular intervals and stopped between projecting blocks of

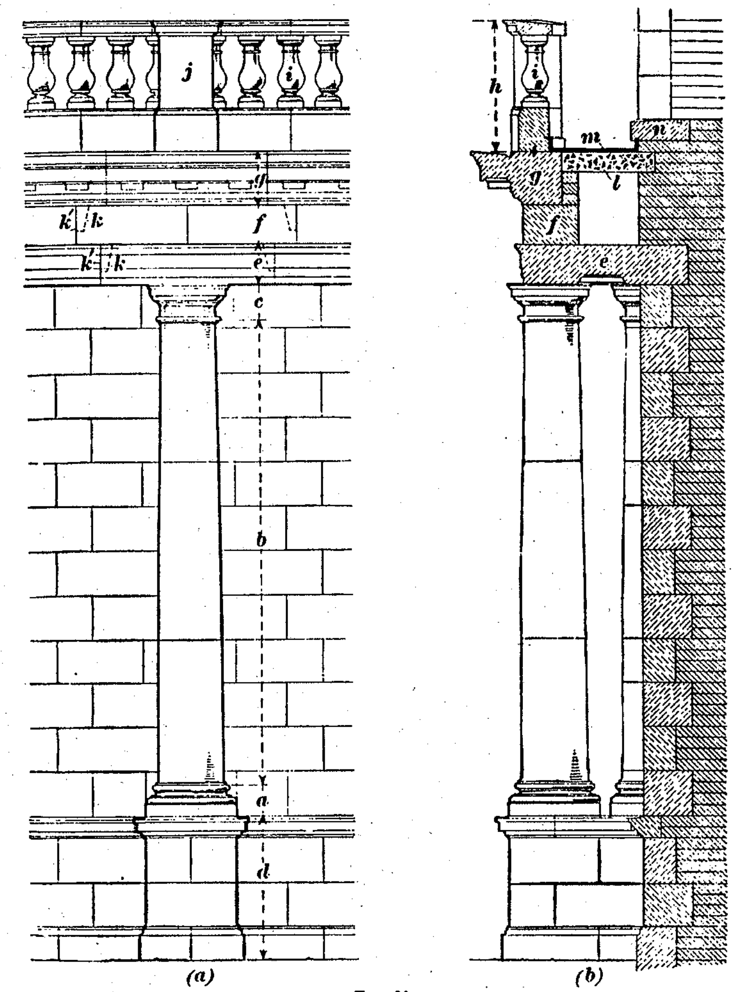
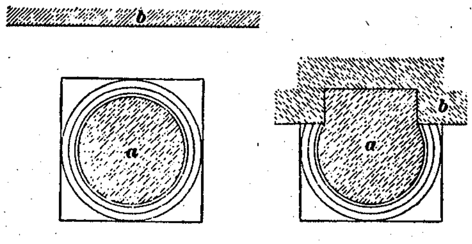


FIG. 20

stone, as shown at j, Fig. 20 (a). In Fig. 20 (a) is shown the elevation and in (b) the section through the entablature and balustrade. **At k, k is shown dotted the rabbeted joint to the** stones forming the architrave and frieze, as described for Fig. 13 (*a*) and (*b*), the only difference being that in Fig. 20 (*a*), at *k*, the rabbets in the joint are stopped before they appear on the face of the joint, so that a straight joint as at *k'* shows on the face. At *l*, in view (*b*), is shown the concrete flat behind the balustrade covered with asphalt *m* to keep the wet from entering the wall. At *n* is the stone sill to a window in the main wall of the building.



(*a*) (*b*)

FIG. 21

28. Blocking Course.—A course of stones built on top of a cornice, partly to tail the same down and partly to form a satisfactory finish to the roof, as shown at *a*, Fig. 22, is called a **blocking course.**

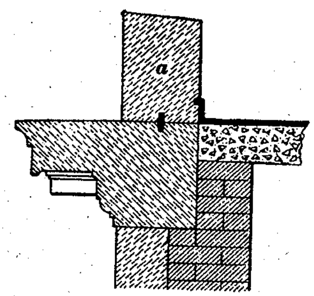


FIG. 22

29. Pediments.—A pediment is an architectural feature in classic architecture often of a triangular shape resembling a gable at the end of a building, following the slope of and forming a stop to the roof. It is usually surmounted by a series of mouldings or cornice. A pediment is frequently used as a decorative feature over a door or window opening, or over a portico, quite apart from the outline of the roof from which it was originally derived. In Fig. 23 (*a*) is shown the elevation and in (*b*) the section of a pediment over a window opening, of triangular form, where *a* is the window head and *b* the pediment; but pediments are often formed with curved outline, as shown in Fig. 23 (*c*) and (*d*). The triangular space *c* contained between the horizontal and raking mouldings of a pediment is called the ***tympanum.***

* * *

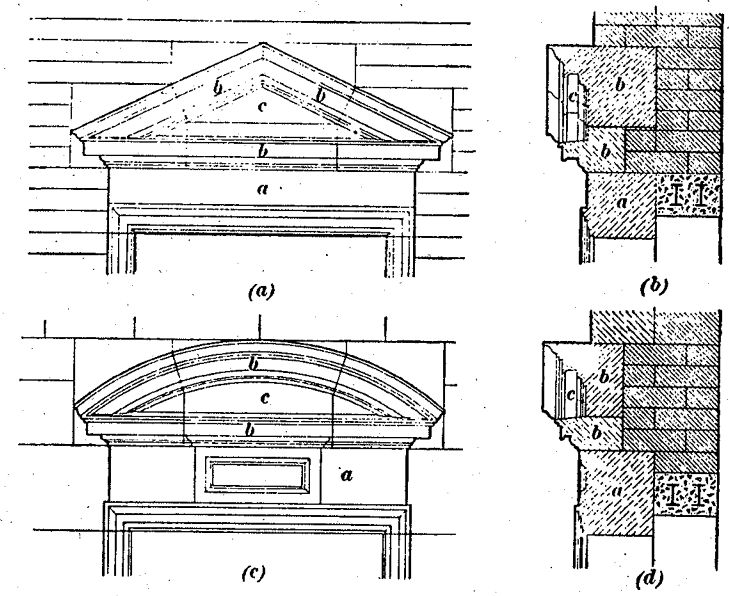


FIG. 23

Sunk.—Any labour executed below the plane of the surface originally found, such as panels, weathering of sills, etc., Fig. 26 (*a*).

Moulded.—The labour required in forming a shaped profile to the edge of a block, Fig. 26 (*a*). At *a* is shown by dotted lines the original shape of the block before the mouldings were worked.

Rubbed.—The labour required in producing the smoothest face possible ; it is generally done by rubbing the face to be finished with a piece of similar stone, adding sharp sand and water, and gradually reducing the quantity of sand.

Polished.—The same as rubbed, and performed in a similar manner, but only on stone sufficiently hard to take a polish, such as marble, granite, etc.

Circular.—The labour required in forming any block into a convex or cylindrical form, such as the shaft of a column when the diameter does not vary, as shown at *a*, Fig. 26 (*b*).

Circular Sunk.—The labour required in forming concave cylindrical surfaces, such as the soffit of an arch or a large hollow moulding, Fig. 26 (*c*). The dotted lines *a*, *a* show the original shape of the block of stone.

Circular Circular.—The labour required in forming plain surfaces that are convex in all directions, such as the exterior of a dome or a circular column with an entasis, Fig. 26 (*d*). The original shape of the stone is shown at *a*, *a*.

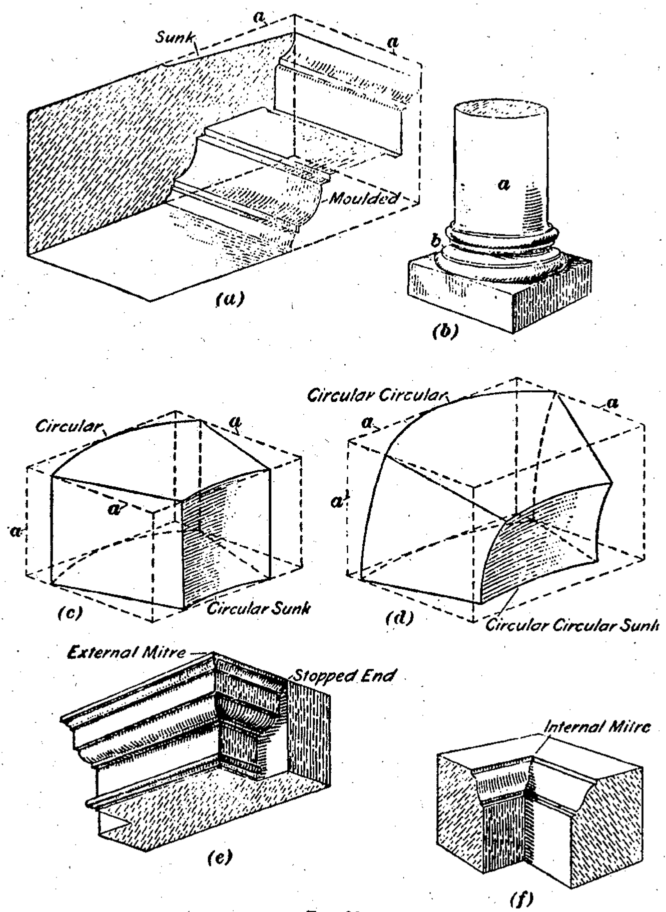


Fig. 26

Circular Circular Sunk.—The labour required to plain surfaces that are concave in all directions.

STONE WALLS

CONSTRUCTION OF WALLS

36. Stone walling is usually divided into three classes: *rubble, block in course*, and *ashlar*. It may be constructed entirely of stone or partly of stone and partly of brick,

* * *

39. Setting Stonework.—In erecting stonework, care should be exercised to have the stone set on the natural bed, that is, on the same surface or bed as that on which it was resting in the quarry, with good joints.

* * *

RUBBLE WALLS

41. Definition.—**Rubble work** is a general term for masonry in which the stones are of various and irregular sizes, and, in most cases, small. It is usual in describing this class of work to add some secondary title to show what kind is wanted. In all cases, the beds of the stones are roughly prepared with the hammer, and sometimes with the chisel and mallet, or the punch. The face of the stones may be dressed differently, generally as best suits the nature of the stone and the cost.

* * *

42. Field-Stone Walls.—In Fig. 27 is shown a **field-stone wall,** or **dry-stone dyke.** Walls of this kind are built of small, uncut boulders or quarried stone without any bedding or jointing, and, in stone districts, are frequently employed for field fences and rustic-house work. These walls are built thick and tapering in section, usually about 5 feet in height, bonded with long stones in the centre of the height, and coped with the larger stones. Sometimes the copings are set in lime mortar, which adds greatly to the strength and life of the wall; occasionally they are coped with layers of turf.

43. Random Rubble Walls.—Fig. 28 shows **random rubble** masonry, which is much used in country districts. The *quoins,*

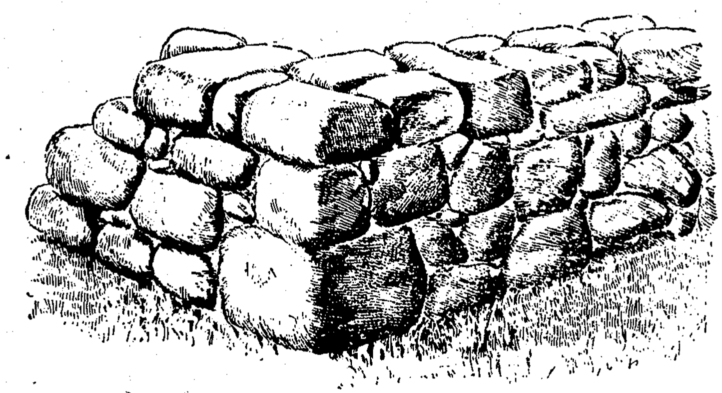


Fig. 27

or corner stones, *a*, are hammer-dressed on top and bottom beds, and may be either cut stone or rock face; the latter harmonizes well when stones similarly dressed are in the body of the wall.

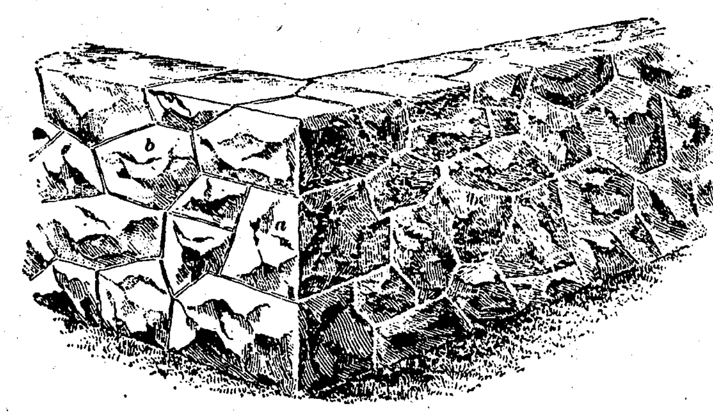


Fig. 28

All joints should be hammer-dressed, as shown at *b*, and no spalls should show on the face, while the mortar joints should not exceed $\frac{1}{2}$ inch in thickness. This makes an effective wall, especially for country churches, lodges, and other small buildings; but the work is expensive, owing to the labour required in dressing the beds and joints.

44. Fig. 29 represents a better kind of random rubble wall, the stones being of irregular shapes, but roughly squared, without regular beds and joints, and bonded about every 4 or 5 feet, as shown at *a*; the largest and best stones should be placed at the bottom and at the angles, as indicated at *b*, set in alternate courses of headers and stretchers. Such work is generally set

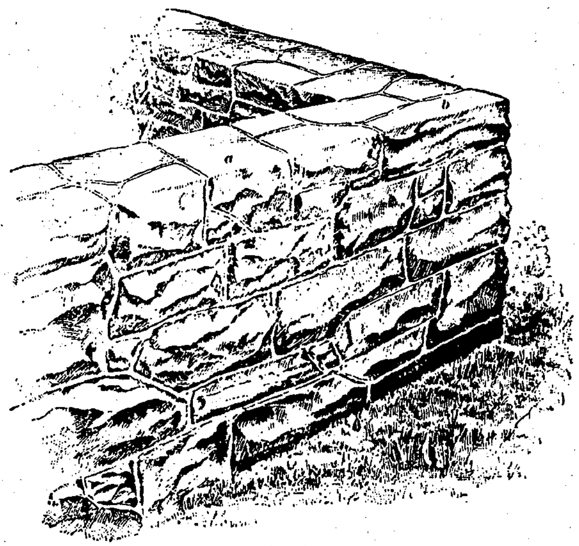


FIG. 29

with beds and joints roughly dressed to fit one another, the stones being set irregularly in the wall in lime mortar and pointed on the face, and the interstices filled with spalls and mortar. If better work is desired, the joints and beds of the stonework should be hammer-dressed. The walls are sometimes flush-pointed and keyed on the joints, or pointed with coloured mortar, showing raised joints.

45. Random Rubble Built in Courses.—Rubble built up to courses, as shown in Fig. 30, is common in some parts of the

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country, and consists of rubble built so that, at intervals of from 12 to 18 inches, a true and horizontal bed is formed, set

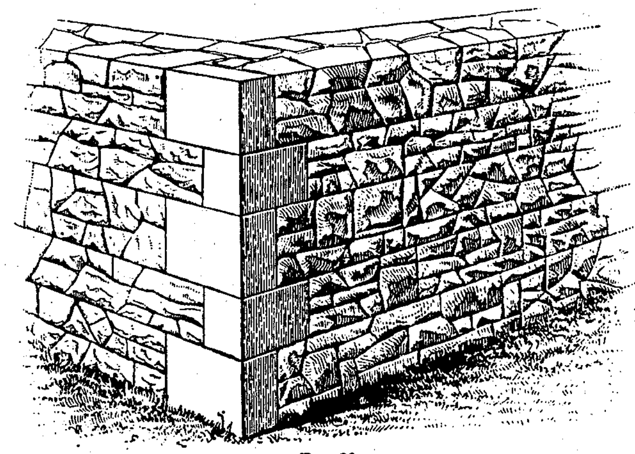

FIG. 30

out to correspond with the corners and dressings. In some cases the wall is built of irregular coursed rubble with bonding

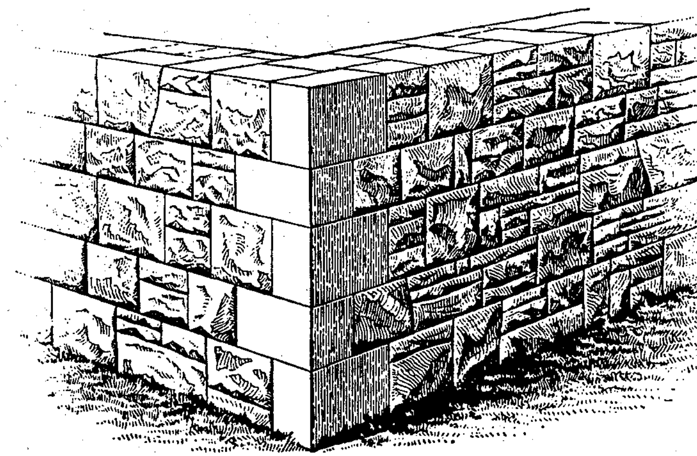

FIG. 31

blocks in each course equal to the full height of the course in which they occur, as in Fig. 31; such work is usually termed *coursed header work*, and the headers in such a wall should equal about one-fourth of its superficial area.

46. Irregular coursed rubble, or, as it is more frequently termed, **squared and snecked rubble,** is illustrated in Fig. 32. In this class of work the vertical joints are usually square and the beds horizontal. The latter run through the length of several stones, but not continuous for more than a few feet, and may be broken at any point to fit in a stone of greater depth. *Snecking* is fitting and filling in smaller stones to complete the shallow courses and bring up the beds to a level.

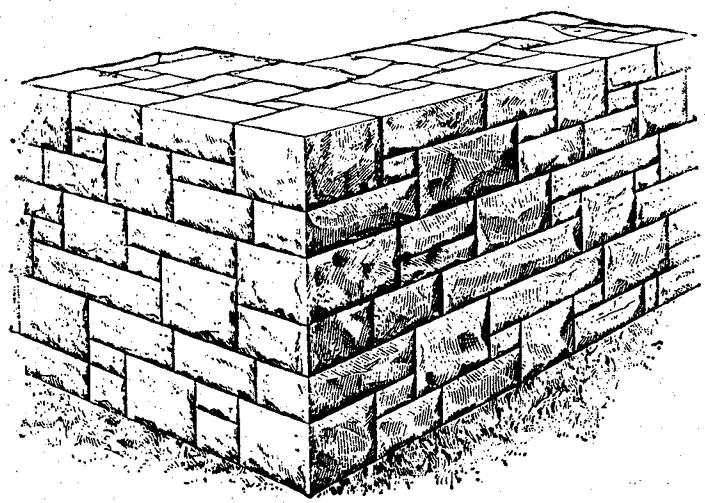

Fig. 32

In regard to the best method of proportioning the blocks and arranging the same so as to produce a harmonious effect, it is first necessary to consider what the various heights of the blocks must be in order to form good longitudinal bond. Assume the lowest heights at 3 inches, as a stone any thinner than this presents an appearance of weakness, and the greatest height at 12 inches, as any stone higher than this looks too heavy for random coursed rubble; the graduations may then be 3, 4, 5, 6, 7, 8, 9, and 12 inches, thus giving eight heights, a variety that, when well arranged, produces a pleasing effect.

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If the highest number is taken at the *jumper* or course leveller, the other numbers will agree with it as follows: $3 + 9 = 12$; $4 + 8 = 12$; $5 + 7 = 12$; $6 + 6 = 12$; $4 + 4 + 4 = 12$; and $3 + 3 + 3 + 3 = 12$; or six arrangements.

The next point to be considered is the length of the blocks. The bond, or the lap of the stones over one another, should be, for the thinner blocks, at least 6 inches, and for the thicker ones, 8 inches.

This class of work is more costly than ordinary or coursed rubble owing to the increased labour in dressing and fitting the stones. It is usually rock-faced, but it may be stugged or hammer-dressed. Fig. 33 shows a good example of this class of work, but with some vertical joints bevelled instead of being squared. This, however, is less common and more expensive on account of the extra labour required in dressing and building, but it has a finer and more pleasing appearance.

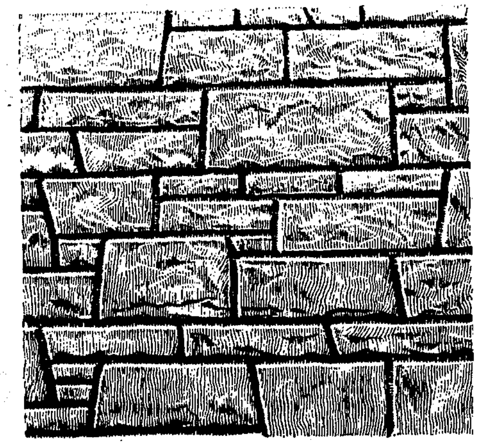

Fig. 33

47. Regular Coursed Rubble.—Fig. 34 shows an example of **regular coursed rubble,** which is used where a more uniform appearance is required and where stones of a fairly uniform size can be obtained. The stones are of various lengths and all the courses are of uniform height. Fig. 35 shows another example of coursed rubble in which the depth of the courses varies, but the stones in each course are of uniform height.

48. Walls With Brick Quoins.—Fig. 36 shows a rubble wall with **brick quoins,** or corners, at *a*. Red brick is usually selected, and the quoins are formed with from four to eight courses of bricks, the dressings, band courses, and openings with arches, being formed with bricks in a similar manner. In this case, all

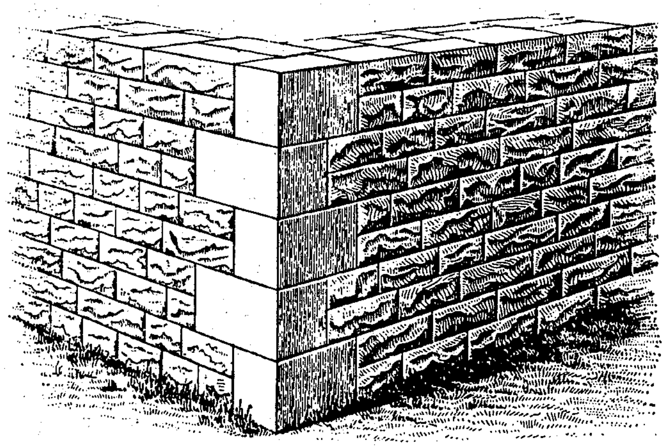

FIG. 34

the top and bottom joints of the rubble work have *level beds*, as at *b*. This makes a very effective wall, and can be built cheaply when the stone used splits readily, or can be laid on its natural

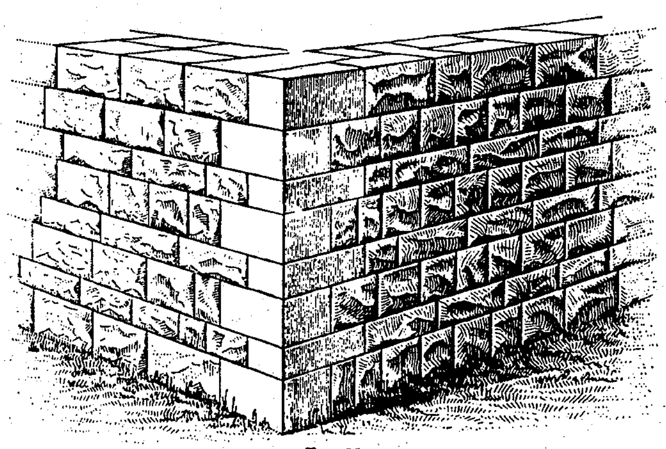

FIG. 35

bed, thus requiring but little dressing, or when good stone for dressings is difficult to get.

***

BLOCK IN COURSE

50. The **block-in-course** method of building, shown in Fig. 41, does not differ materially from coursed rubble, for in this case

the courses are formed with stones of equal height for each course, but differing in length, the courses varying from 6 to 12 inches in height. The walls are of a larger and better quality of stone,

usually squared with fairly fine ends, and the average of the courses is deeper and the joints finer than in coursed rubble work.

Through bond stones are shown at *a*, *a*, Fig. 41. This work is

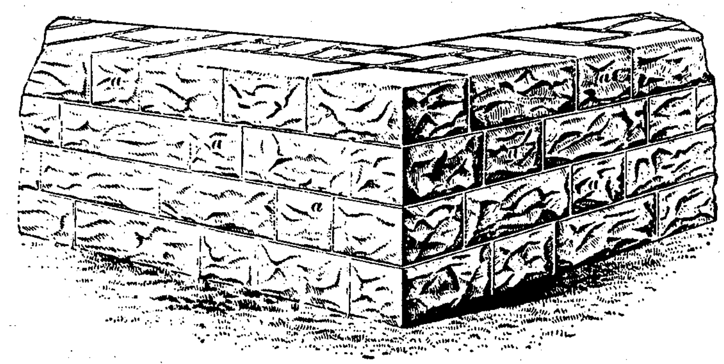

FIG. 41

much used by engineers for the facing of large piers in stone districts.

ASHLAR

51. Definition.—**Ashlar** is the term given to the facings, or veneer of stone, of a brick or rubble wall in which the joints of the blocks are worked as smooth and as true as possible. It is the best class of masonry, the blocks being usually over 12 inches in depth and carefully squared and prepared with fine beds and vertical joints not more than $\frac{1}{8}$ inch thick. In the finest class of ashlar, the courses are of uniform height and worked in regular and uniform lengths, so arranged that the alternate courses bond.

52. Best Stone for Ashlar.—Granite and the most compact sandstones and limestones should be used for ashlar masonry, for, in pitching, the spalls fly off more easily and leave the fracture in sharp lines, whereas with the softer kinds of rock the fracture has a bruised and crushed appearance.

53. Setting Out Ashlar.—If ashlar in regular courses and sizes is to be used, drawings should be made showing each different-sized stone, the heights of the courses, and other necessary details. The drawings for public and office buildings usually show every stone, unless ordinary ashlar is used, in which case it is only necessary to show the quoins and jambs on the drawings, together with enough of the ashlar to indicate the character of the work desired.

54. Cutting Ashlar.—In cutting ashlar, no stone should have a bed less than 7 inches wide, and for first-class work the width of bed should equal the height. Larger stones should also be worked in as headers or bond stones, and should be cut accordingly. All the beds should be cut true to the square, or the width of bed will be of little value; the backs also should be roughly cut, in order that the work may be solidly built. The vertical joints may be cut a *little slack* to the square on the back, thus forming a dovetail of the mortar; but the greatest care should be taken to cut the level beds true, so as to prevent rain-water from soaking into the wall. The backing should be carefully brought to the same levels as the facework courses, and no headers should be shorter than 16 inches on bed nor placed more than 10 feet apart in each course.

55. Dressing Ashlar.—In dressing ashlar, the first finish to be considered is the plain rock face, which, although the simplest, is not the least effective. The block must first be cut true and square all round, forming beds and vertical joints, after which straight lines are drawn round the edges, about 2 inches

from the face of the block, and made perfectly true out of wind with one another. Then a wide pitching tool is used to cut along these lines, knocking off the surplus material and leaving the face free from tool marks. If, however, the block is very large on the face, it is sometimes necessary to regulate this face by using a pointed tool, working from the centre outwards, and obliterating the tool marks as the work proceeds. When finished, the face should have a somewhat regular broken appearance, with about 2-inch projections from the setting arris. Sometimes, window and door openings are left rock-faced in the reveal, but such practice leaves the lines of these openings too undefined and unshapely. It is considered that the best method is to cut the reveals clean in all openings, with either a tooled or rubbed finish. The regular band courses should also be clean cut, as by so doing the surface is broken up much better and the rock-faced work is shown off by contrast.

56. Fig. 42 shows an ashlar wall where the pieces are uniform in size; when such stones can be obtained readily, this is not

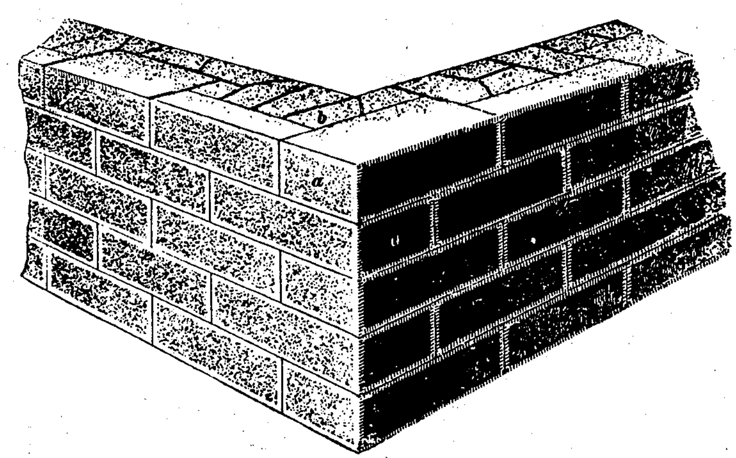

Fig. 42

a very expensive method. The ashlar *a* and the backing *b* consist of ordinary rubble. A good effect is produced by making the courses so as to be of two heights, but cut in regular sizes, and having the vertical joints in alternate courses directly

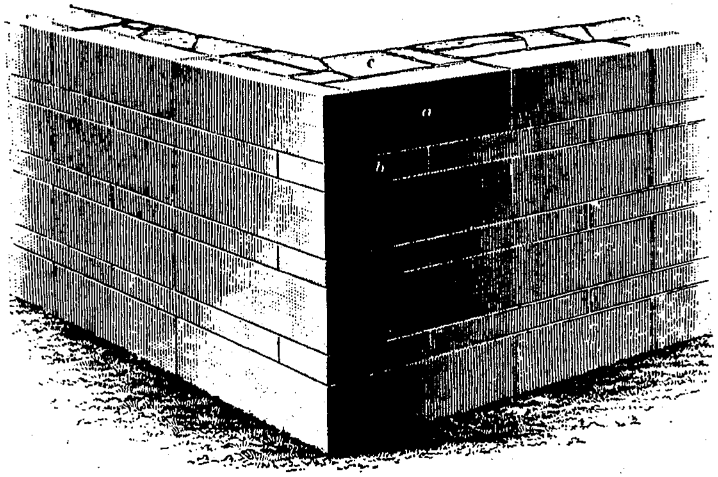

FIG. 43

over one another. This class of work is shown in Fig. 43, in

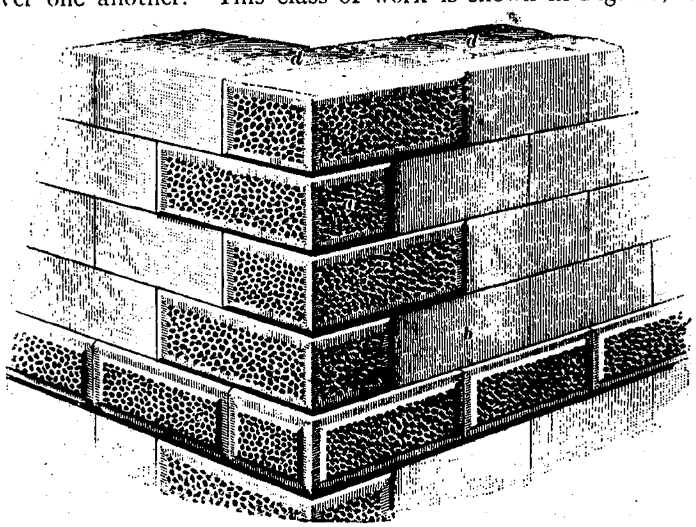

FIG. 44

which *a* is a 14-inch course; *b*, a 6-inch course; and *c*, the

backing. The latter may also be brick, as the ashlar can be well bonded into it. If the narrow band course *b* is rock-faced, or has some different finish than the wide courses *a*, the appearance of the work will be further improved.

57. The stonework of many public and office buildings has rustic quoins and base or band courses, as shown in Fig. 44. Here, *a* indicates the quoins, having a 1-inch bevel, or chamfer, at the joints; *b*, the plain, rubbed, or tooled stones forming the face of the wall; *c*, the rustic band course, having a $1\frac{1}{2}$-inch chamfer cut on it, so as to project beyond the quoins; and *d*, *d*, the stone or brick backing.

58. Among other forms of working plain rustic ashlar may be mentioned the shallow rebate round the edge of each stone, the joint being at the top of the rebate and not at the bottom, as worked this way water is less likely to penetrate at the joint. Another method is the **V** joint, a chamfer being worked all round the edge of each stone and at the vertical joints. When rusticated or vermiculated surfaces are given to the stones, increased prominence is given to them by the use of a group of small mouldings running round the panels. These are not confined to the rectangular blocks of plain walling, but may be used to emphasize the large blocks or voussoirs forming an arch, and in large structures often fulfil an important part in the design. These methods, however, are very expensive, owing to the great amount of dressing required.

59. Setting Ashlar.—Ashlar is laid in regular courses with continuous horizontal joints, as in Figs. 42, 43, and 44, or worked with headers *a* and stretchers alternately, Fig. 45, much the same as Flemish bond in brickwork. Ashlar is not always as regular as this, for both the courses and the separate stones may vary in size, but all have straight and horizontal beds, and the vertical joints are kept plumb; failure to do this mars the effect very materially. In forming ashlar walls, it is not unusual, when a plain face is adopted for the general surface, to use vermiculated or rustic quoins and band courses, as in Fig. 44, and, with certain styles of architecture, to mark the outline of every stone by a sinking, thus giving more variety and character to the building.

In laying the stones, the dry stone should be fitted for the position, and then the bed should be prepared and the stone put into its place. It should then be tested with the spirit level,

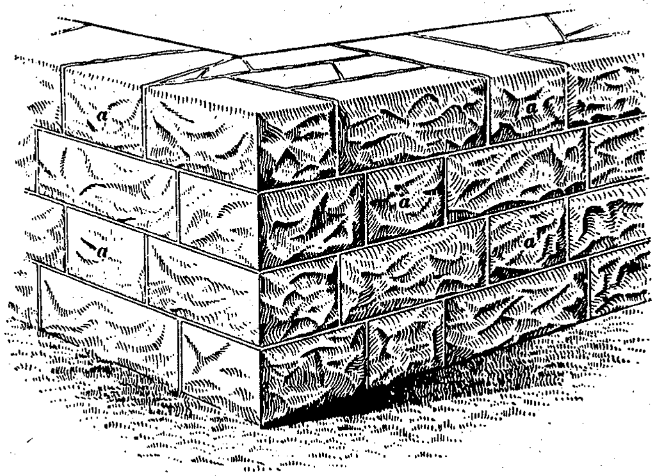

Fig. 45

and if not perfectly true should be slightly shifted with the help of a wooden mallet. If this is insufficient, it must be raised and the mortar bed adjusted where necessary, so that the stone may be set level. Great care is required to see that the mortar is spread truly and evenly, otherwise there is danger of fracture due to uneven settlement.

60. Backing Ashlar.—The expense of ashlar masonry is such that it is commonly used merely as a facing, being backed with either rubble masonry or brickwork. It is only on works of great importance and solidity that it is used throughout the whole thickness of the wall. The minimum thickness of the ashlar face should never be less than 7 inches, and it should be so arranged that about one-fourth of the total area of the face is built into the backing for at least an additional 5 inches. Stone facework is usually bedded in lime mortar, as cement stains the face of the stone.

Both stone and brick are used for backing, but in most cases brick is the cheaper, and hence is more extensively used. When using bricks, the joints should be made as thin as possible and cement mortar employed, so as to avoid shrinkage; this backing should never be less than 8 inches thick.

61. When a hard laminated stone with flat parallel beds can be obtained, it should be used, as it is considered to be a stronger backing than brickwork. Irregular rubble walls should not be used for dwellings higher than two or three stories, unless the walls are made at least one-fourth thicker than when brickwork backing is used. All backing, whether of brick or stone, should be carried up at the same time and built in courses of the

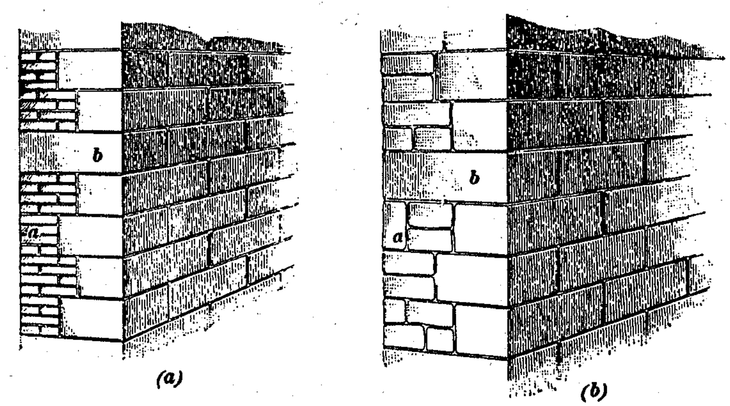

Fig. 46

same thickness as the ashlar. This is illustrated at *a* in Fig. 46 (*a*) and (*b*).

If the courses are not over 12 inches high, they are usually bonded sufficiently to the backing by making every other course thicker, and by having one through bond stone to every 10 square feet of wall, as shown at *b* in Fig. 46 (*a*) and (*b*). This method is called a *toothed bonding*.

62. Ashlar Bonding.—In Fig. 47 is shown an example of a building where the main part is constructed of ashlar and the

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FIG. 47

two towers at the corners are built of squared and snecked rubble. These two styles of masonry form an internal bond, which might be called an *inverted corner*. It will be noticed that the courses in the squared and snecked rubble are so arranged that they come level with the joints in the ashlar, thus permitting the two parts of the building to be toothed, or bonded, together.

63. Fastening Thin Ashlar.—Although not so strong as a toothed bond, an ashlar facing of from 2 to 4 inches in thickness is often used, especially when marble or other expensive stones are employed in the construction. In such cases, each piece of ashlar should be tied to the backing by at least one iron clamp, or anchor, similar to that shown in Fig. 48, while if the stones are more than 3 feet long, two anchors are generally used. All iron clamps, or anchors, should be either galvanized or dipped in hot tar or asphalt, to prevent the formation of rust on them.

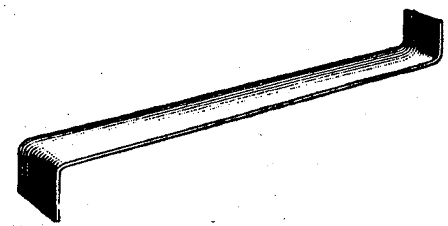

FIG. 48

Belt courses extending 8 inches or more into the wall should also be laid about every 6 feet in height to give support to the ashlar. When a wall is faced with thin ashlar, the effective bearing strength is only that given by the thickness of the brick or stone backing, the facing not being relied on for that purpose.

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meet the top and bottom arrises in points M and N. Horizontal lines drawn through these points determine the vertical height of the joint along the axis of the cylinder.

From point 7 draw the development of the inner and outer cylindrical surfaces as shown. Where the top and bottom arrises of these developments cut the horizontal lines in points $M^3 N^3$ and $M^2 N^2$ determines the points through which to draw the lines representing the development of the joint arrises, thus giving their correct length and bevel. These lines are required on the developed face moulds.

Approximate Development of Helicoidal Surface.—To draw an approximate development of the joint surfaces draw perpendicular lines to the axis line O 7″ in plan, to cut a new axial line drawn parallel to the axis O 7″. Make this new line the entre of the joint. Project the points M^3 7″ N^3 and M 7 N, also M^2 7′ N^2 in plan, as shown, and measure the length of each joint line in development, as at 7 M, 7 N in Fig. 431. Then, with the compasses on point 7 (Fig. 432), and radius 7 M, or 7 N, draw arcs cutting the projectors drawn from M and N in plan in points M and N in development. Repeat this process for the lines $M^3 N^3$ and $M^2 N^2$. Because the vertical height of the joint is the distance travelled along the axis of a cylinder, this length can be transferred to the axis line in development, as shown. A series of curves drawn through the points thus obtained will give the development required.

Setting Out Pediment in Straight Wall.—In setting out full size, it is necessary to draw only sufficient in elevation to obtain the face mould for the *apex stone* and the bed mould for the *springer stone* in plan.

First draw the bottom bed line in elevation and the centre line at right angles to the bed line. Determine the return wall line W, and draw in the true section of the cornice mould between N and W (Fig. 433). From N draw the line N C, representing the rake of the pediment, and draw lines from N′ and X parallel to N C to cut the centre line in E and F. Now draw the plan of the pediment, as shown in Fig. 434, by projecting down from elevation. Next draw a line at right angles N C in any position, and on this line from X′ mark off the vertical heights of the horizontal members between X and W, as at X′ H′. Through these points draw lines parallel to N C to cut the centre line. Terminate these lines on the weathering formed on the top surface of the horizontal cornice as shown. Now draw from point H′ the elevation of the joint lines for the springing stone, and continue the vertical joint to the bottom fillet line of the raking cornice. Draw H′ J′ at right angles to N C. Then the outline for the face mould of the springer stone is complete.

To obtain the outline for the bed mould, drop vertical projectors from H′ J′ into plan as shown.

To work the springer stone, a raking section mould is required for marking on the joint surface J′ H′. This mould may be obtained by an auxiliary plan of the figure on the inclined plane of the joint, or by rabatment. In this example it is obtained by rabatment (see Fig. 435). First draw the *horizontal projection* of the figure lying on the inclined joint plane by dropping vertical projectors into plan, as at J and H. Between points N′ X in elevation mark any number of points. Draw lines from these points parallel to N C to the vertical trace of the joint plane. Also from N′ X drop vertical projectors to cut the

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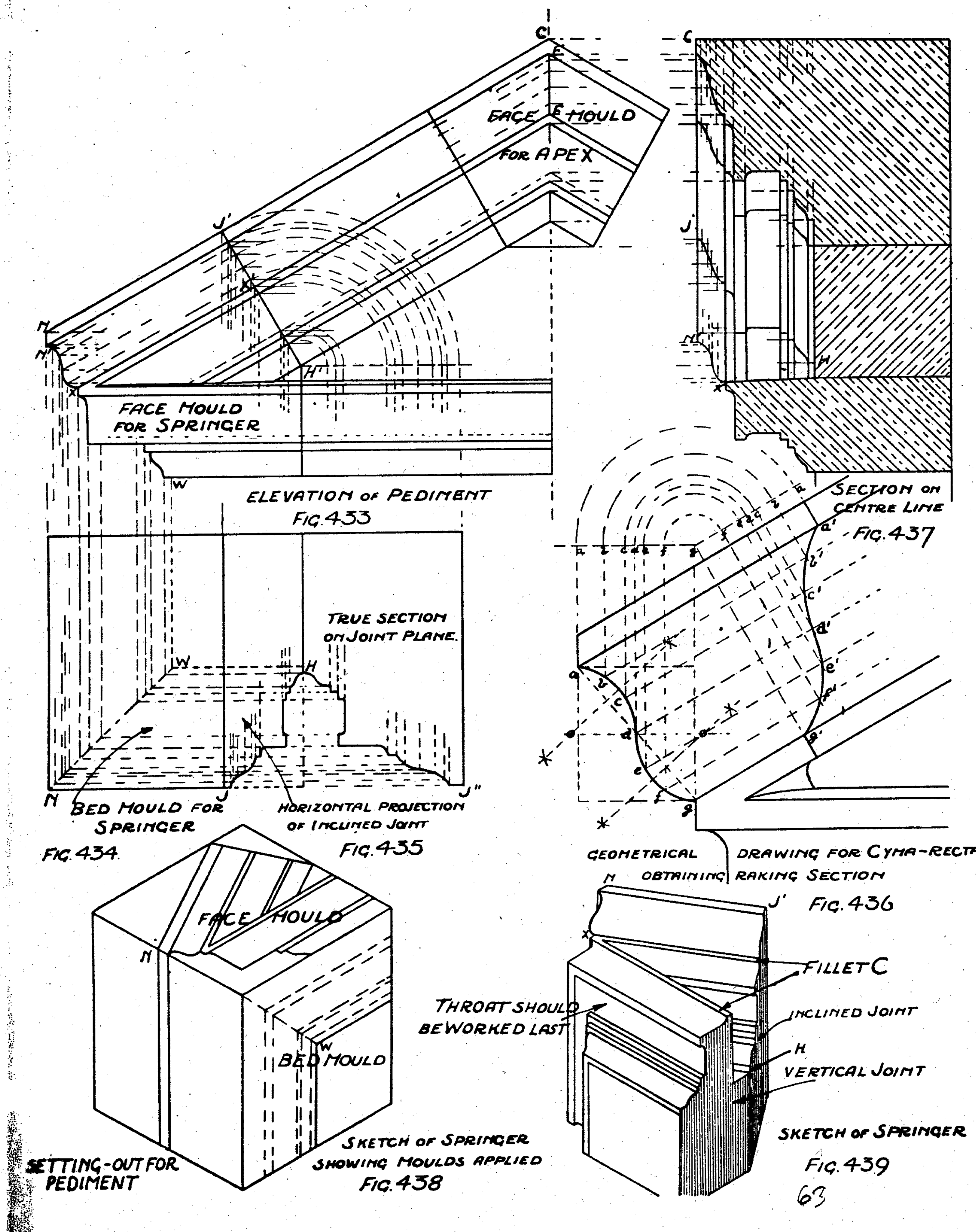

ELEVATION OF PEDIMENT FIG. 433

SECTION ON CENTRE LINE FIG. 437

FIG. 434

FIG. 435

GEOMETRICAL DRAWING FOR CYMA-RECTA OBTAINING RAKING SECTION FIG. 436

SETTING-OUT FOR PEDIMENT

SKETCH OF SPRINGER SHOWING MOULDS APPLIED FIG. 438

SKETCH OF SPRINGER FIG. 439

mitre line N W in plan. From these points in plan draw horizontal projectors to meet vertical projectors drawn from the V.T. of the joint plane, thus completing the outline of the moulding as shown.

With H′ as centre, swing all the points in the V.T. of the joint plane, into the horizontal plane to intersect horizontal projectors drawn from their corresponding points in the horizontal projection. The true shape of the section lying on the inclined plane is now obtained.

A diagram showing the geometrical construction for obtaining the true section of the cyma-recta moulding by projection is shown in Fig. 436. Fig. 437 is a section on the centre line of the pediment, but this is not essential to the setting out.

A sketch of the stone showing the face mould and bed mould applied is given in Fig. 438, and a sketch of the finished springer is given in Fig. 439.

Setting Out Segmental Pediment in Straight Wall.—The example chosen is taken from Fig. 191. As previously explained, this feature must be set out full size in order that the correct sizes and the necessary moulds for working the stones may be obtained. It is only necessary to draw in elevation sufficient beyond the centre line to obtain the face mould for the *apex stone*, and in plan sufficient to obtain the bed mould for the *springer stone*. First draw the bottom bed line and the centre line in elevation (Fig. 440). Determine from the scale drawing the position of the centre line of shaft at X, and place in the lines representing the top bed line of the frieze immediately over the capital. This determines points *w* and *y* in the elevation set out. Mark in the true section of the cornice mould from point W, thus determining point N′. Next fix the height of point C above the bottom bed line, and obtain the centre for striking the segmental raking nose line N′ C, and draw the lines representing the member lines of the raking cornice as explained in the previous example.

Draw the plan as shown in Fig. 441, by projecting from elevation, the position of the wall lines being determined from the scale drawing or setting out of the doorway (Fig. 191).

From point Y in elevation, place in the section of the lower members of the cornice, giving the outline for the return of the nosing, as at point E. This point determines the position for the vertical joint, which should now be drawn to intersect the bottom bed line of the raking cornice at F. From F draw the normal joint line F H. Drop points E and H into plan, thus determining the outline of the face mould and bed mould for the springer stone.

The method of obtaining the raking joint mould is shown by projecting lines from the various points in the V.T. of the joint plane at right angles to the V.T., and measuring their projection from the wall line, these distances being taken from the true section of the cornice in elevation between N′ and W. This raking section could be obtained by drawing a section on the centre line, as shown in Fig. 442.

The geometrical construction for obtaining the raking section of the ogee is shown in Fig. 443.

Setting Out Semi-elliptical Skew Arch.—Draw the elevation of the arch on the outside wall line, placing in the normal joint lines for the voussoirs (Fig. 444).

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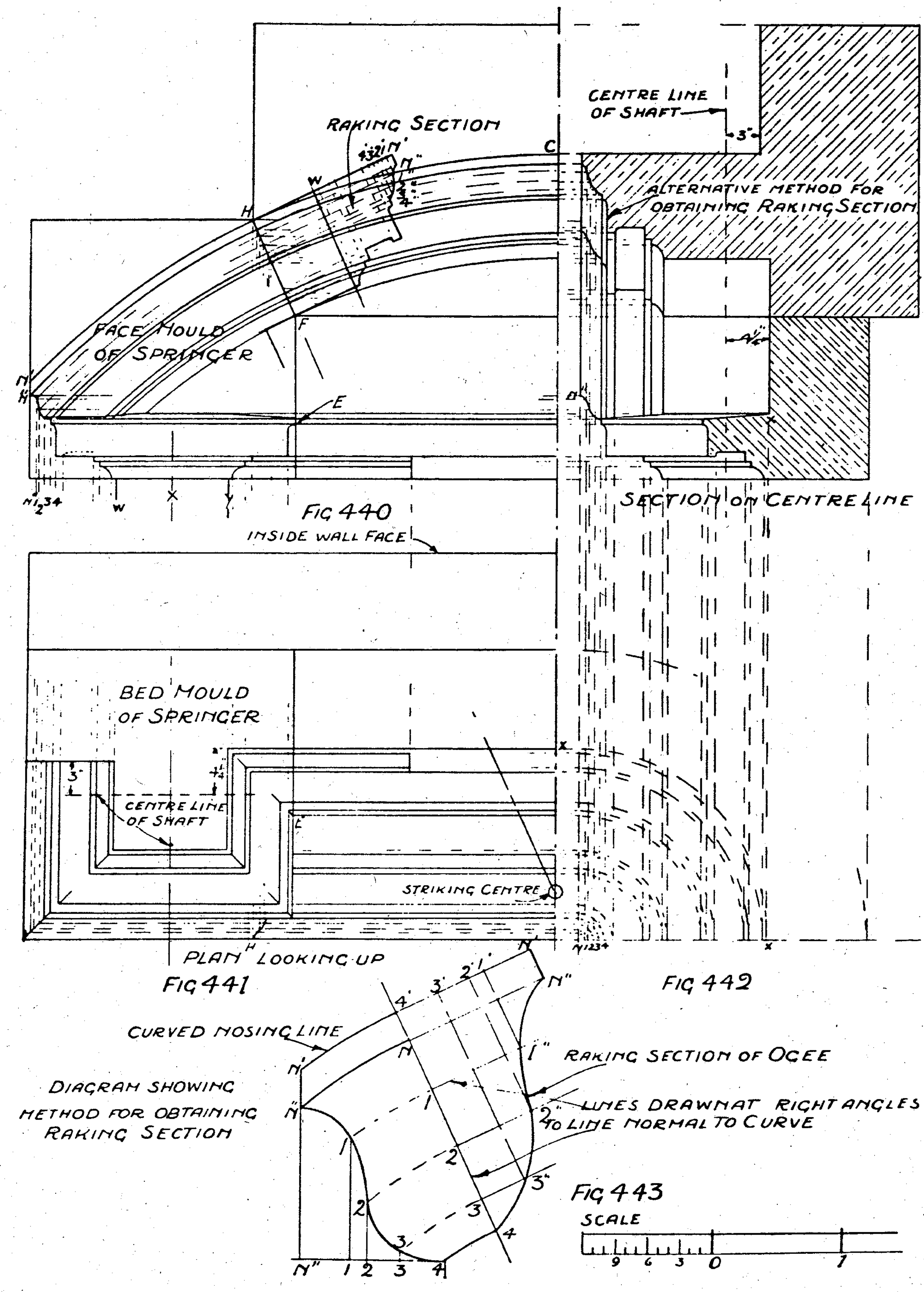


SETTING OUT OF SEGMENTAL PEDIMENT.

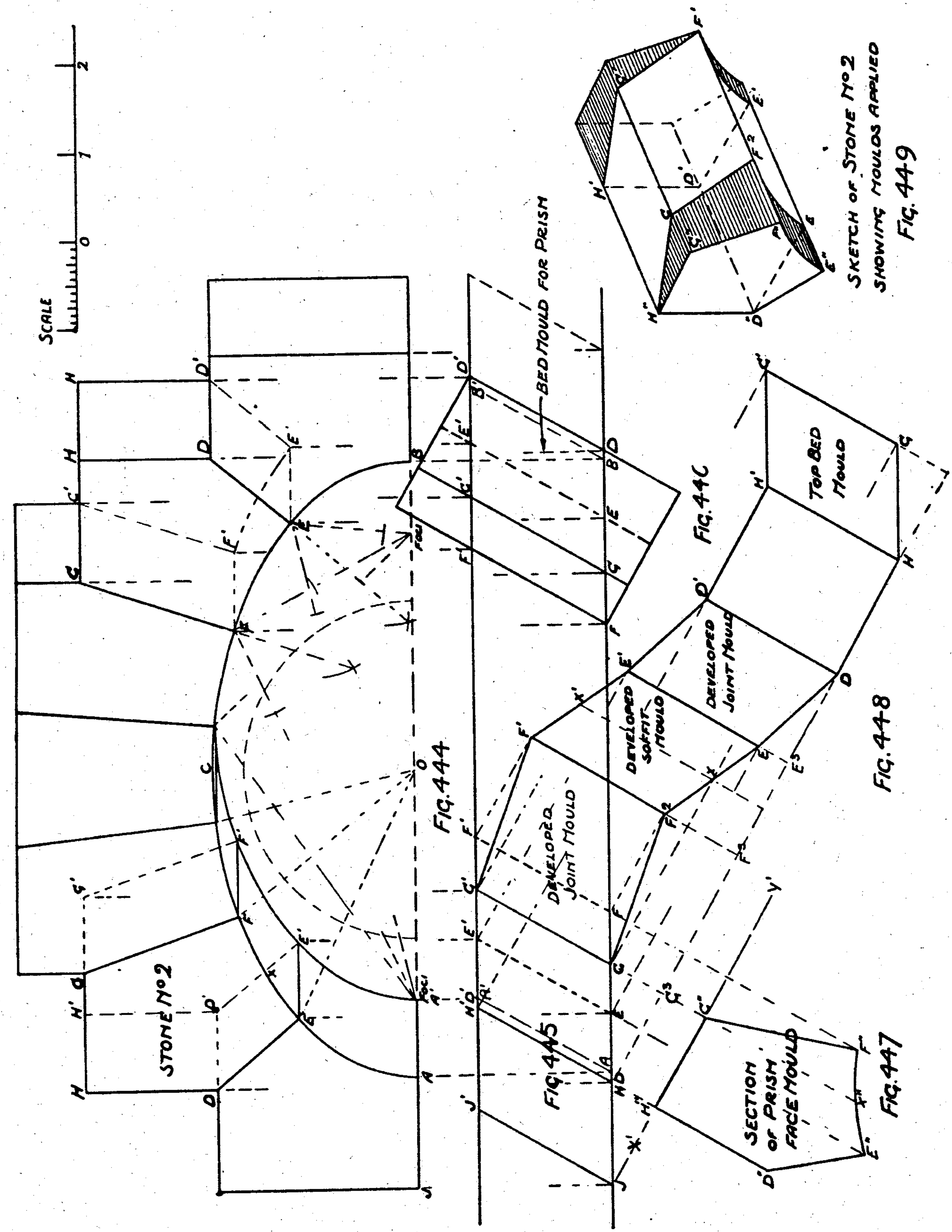
Next draw the inside and outside wall lines in plan, and project vertical lines from the points A E F, etc., in elevation to cut the outside wall line in points A E F, etc. (Fig. 445). At point A in plan, place in the *angle of skew* determined by the line A A′, which represents the plan of the arris line at the bottom bed of the springing stone. Where this line cuts the inside face of the wall at A′, draw a projector up to the springing line in elevation in point A′, thus determining a point from which to draw the elevation of the arch curve on the inside wall face. Points E′ and F′, etc., are projected in a similar manner, thus obtaining a series of points, as at E′ F′, through which to draw the elevation of the inside arch curve.

To obtain the moulds for stone No. 2, project the points E F G H D down to the outside wall face, and from these points draw lines parallel to A A′ in plan to the inside wall face.

It will be found most economical to work the stone from a prism instead of a block viewed at right angles to the wall face.

The method of obtaining the bed mould of the prism is shown on the right-hand side of the plan (Fig. 446). When this is determined, it is necessary to project a true section of the prism. This may be done by drawing an *auxiliary elevation* at right angles to the long edges of the prism, thus: Produce the plan lines of the arrises of the prism to cut a new X′ Y′ line drawn at right angles to the plan lines. Measure the heights of the various arris lines in elevation and mark their heights in front of the new X′ Y′ line, as shown in Fig. 447. It is now necessary to obtain the development of the surfaces of the prism. To do this, unfold the surfaces commencing from the arris line G G′, then all the arris points will travel along paths at right angles to G G′. From H draw a line at right angles to G G′. Project the line G G′ to meet this line in G^3. From G^3 mark point F^3 on the line drawn from H, the distance being equal to G″ F″ measured from the section mould of the prism. Project a line from point F in plan to meet a line drawn from F^3 parallel to the line A A′ in point F^2. Join G F^2 and G′ F′, thus obtaining the developed joint mould. Develop the other surfaces in a similar manner, as shown in Fig. 448.

A sketch showing the application of the moulds on the surfaces of the prism is given in Fig. 449.



SEMI-ELLIPTICAL SKEW ARCH.

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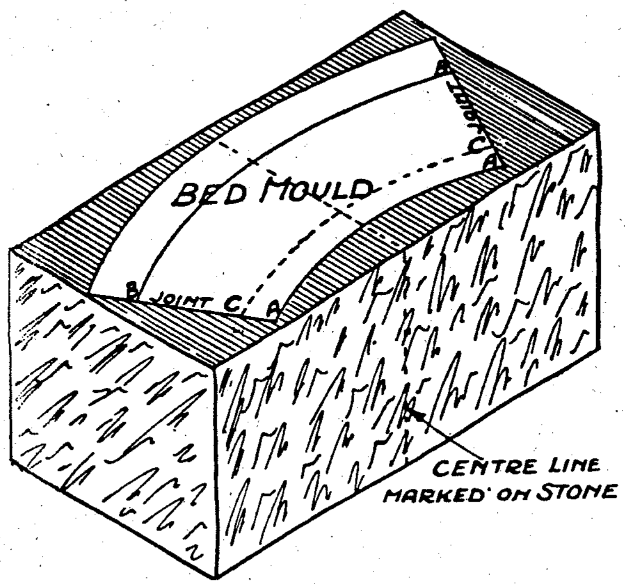

FIG. 273.

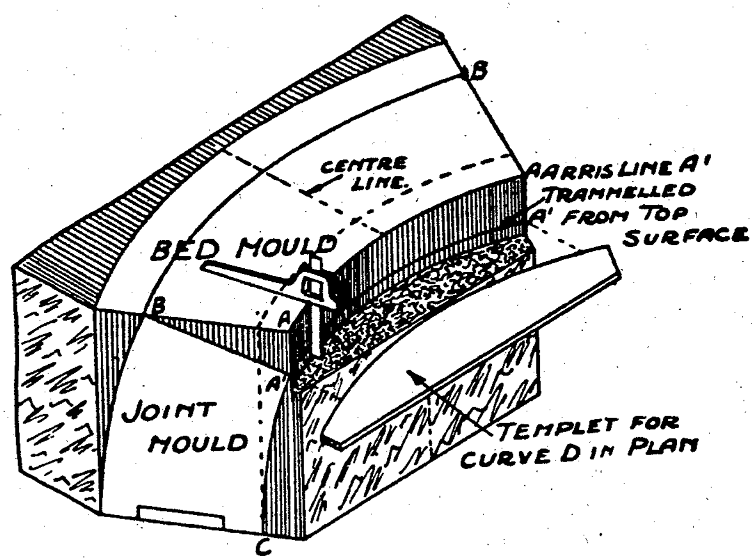

FIG. 274.

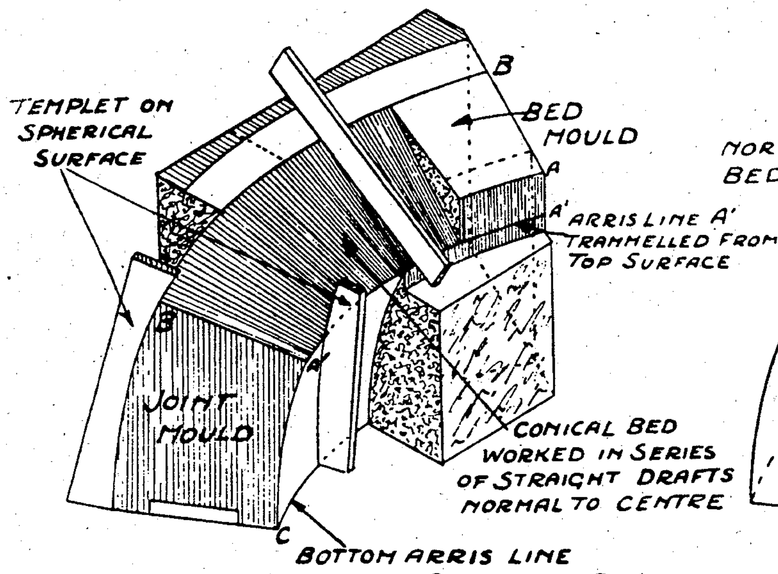

FIG. 275.

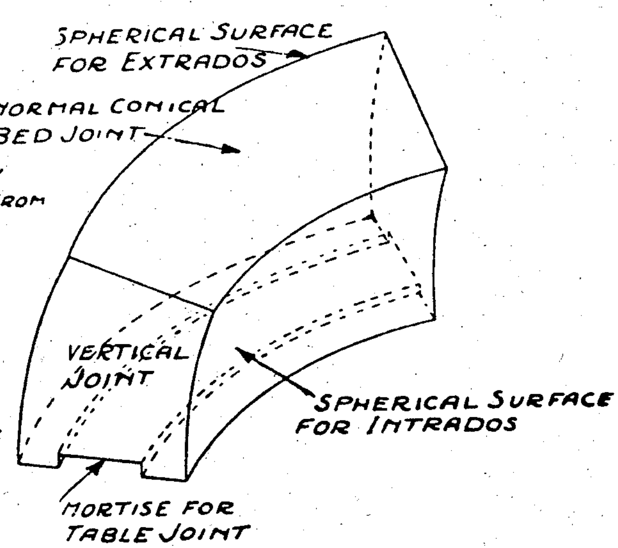

FIG. 276.

WORKING DOME STONE.

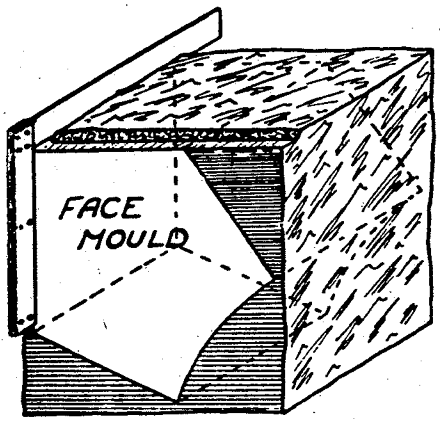

FIG. 249.

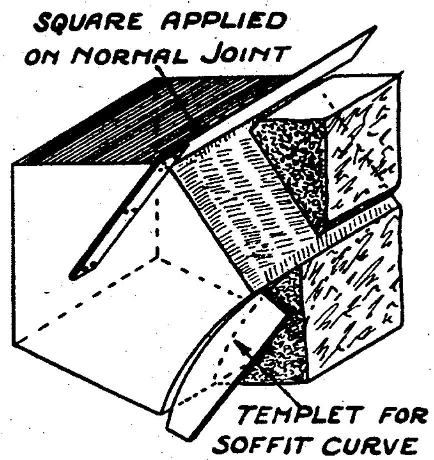

FIG. 250.

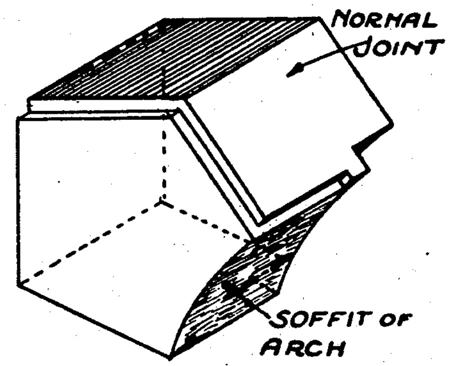

FIG. 251.

WORKING A VOUSSOIR.

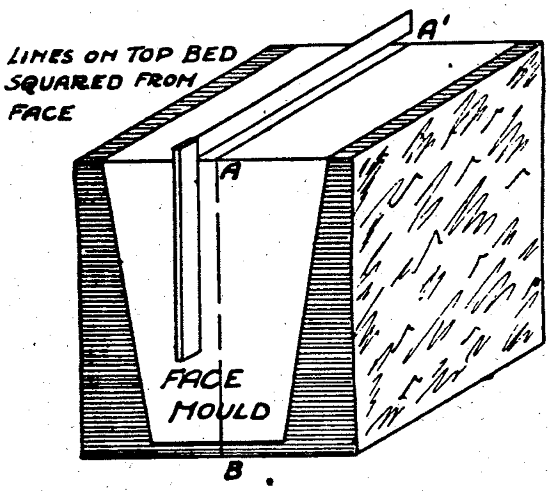

FIG. 252.

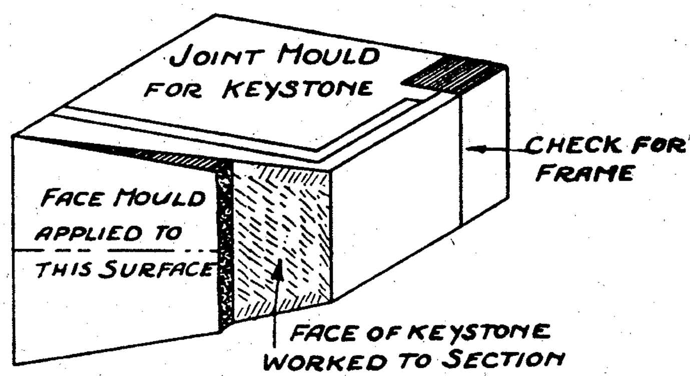

FIG. 253.

WORKING A KEYSTONE WITH SLOPING FACE.

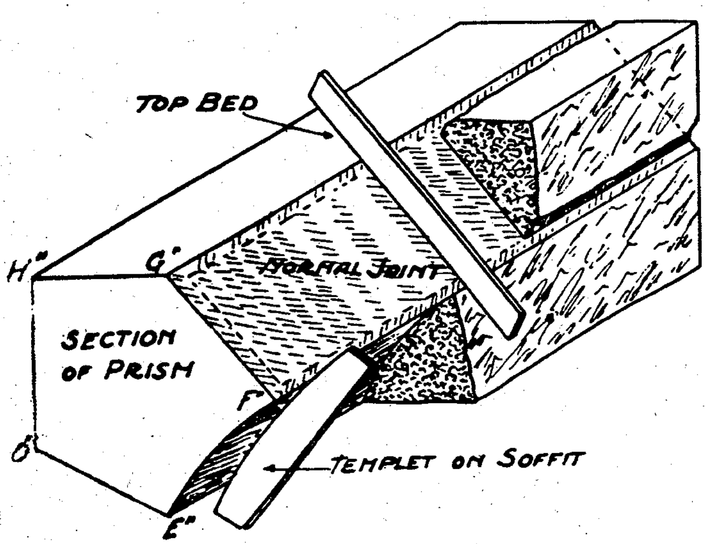

FIG. 254.

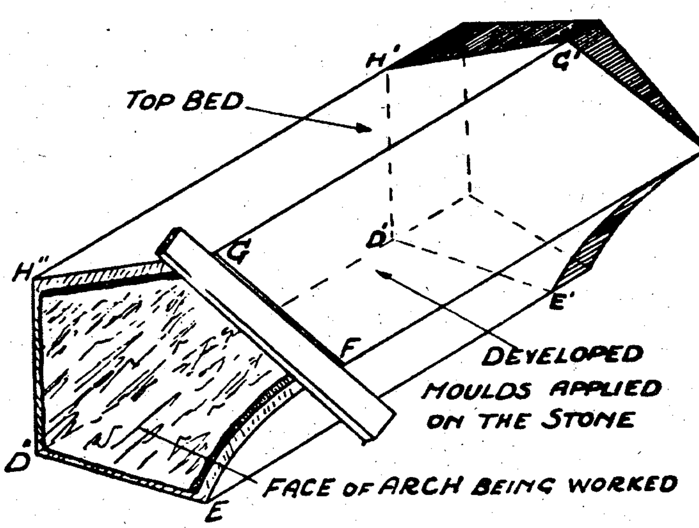

FIG. 255.

WORKING VOUSSOIR FOR SKEW ARCH.

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this until the moulding has been worked, so that the stone may be worked back if required.

Working Mouldings by Hand.—Mouldings and cornices are usually run through by machines, but it is essential that the processes necessary to execute them by hand be explained.

No definite method for the working of mouldings can be stated, as each craftsman evolves a method peculiar to his own style. The difference in the texture of the various stones calls for different procedure: the general principles are, however, the same. For instance, mouldings on Bath stone are worked differently from mouldings in Portland stone, whilst marble calls for a treatment differing from either. It is not advisable to cut marble direct into sharp angles, because the material is liable to fly owing to its brittle nature. The

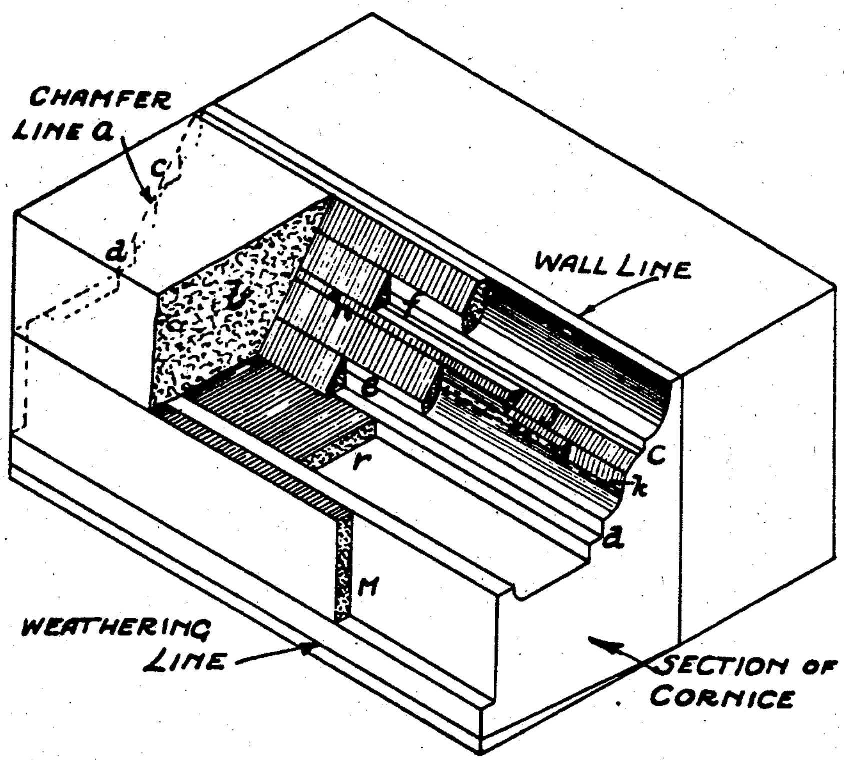

FIG. 243.—WORKING CORNICE BY HAND.

mouldings in Bath stone may be *sawn* direct into the fillets with a *fillet saw*. Fig. 243 shows the method of working mouldings in Portland and similar stones by hand.

The group of mouldings forming a cornice must be worked in stages, or a series of sinkings, each sinking preparing the way for the finishing of the group.

Commence by marking on the chamfer line *a*, and work out the check *b* down to the level of the drip. Now produce the fillet lines at *c* and *d* to intersect the chamfer line *a*, and work the small checks as at *e* and *f*. Mark on the arris lines for the *cavetto* mould and also the hollow portion of the *cyma recta* (ogee), and produce this curve to meet the chamfer line *a* in *h*. Complete the outline of the *cyma recta* by marking and working small tangents, as at *j* and *k*. Next work the front fillet *m*, and lastly the throat *r*.

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To Work Circular Mouldings (Fig. 244).—Assume the circular stone already described in Figs. 240 and 241 to be a moulded *voussoir* or *arch-stone*, irrespective of the direction of the *bedding planes*. The *bed mould* would now be the *face mould*, the convex surface and the joints being already worked. The concave surface may now be worked to the outline of the mould, in a manner similar to that described for the convex surface.

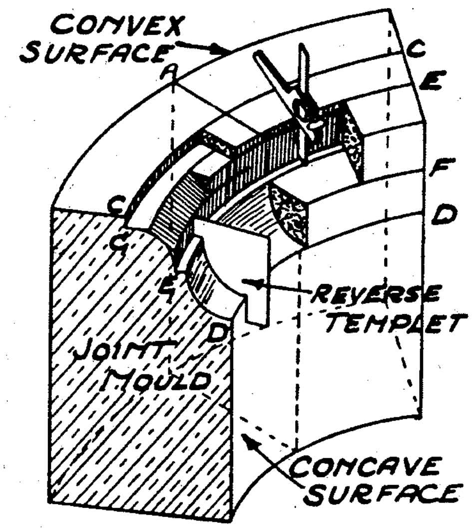

FIG. 244.—WORKING CIRCULAR MOULDINGS.

The joint moulds, giving the section of the arch moulding, are now marked on the normal joints. Trammel the lines of the moulding at C C, round the face of the stone from the convex surface, also trammel the arris line D along the concave surface, parallel to the face of the stone. Now square the angle of the fillet E to the face of the stone, and extend it out to the concave surface at F. Trammel these lines as before, and work out the check to these lines, testing it with a *sinking square*, from both surfaces. Next repeat the process for fillet G. A series of tangents marked to the curve of the *ovolo* moulding, and worked as shown in the figure, will complete the contour of this member. The *cavetto moulding* may now be worked by trammelling the arris line of the fillet E parallel to the concave surface, the exact shape of the hollow being obtained at each joint by working a draft to the section marked on the stone, and being tested with a reverse templet of the hollow.

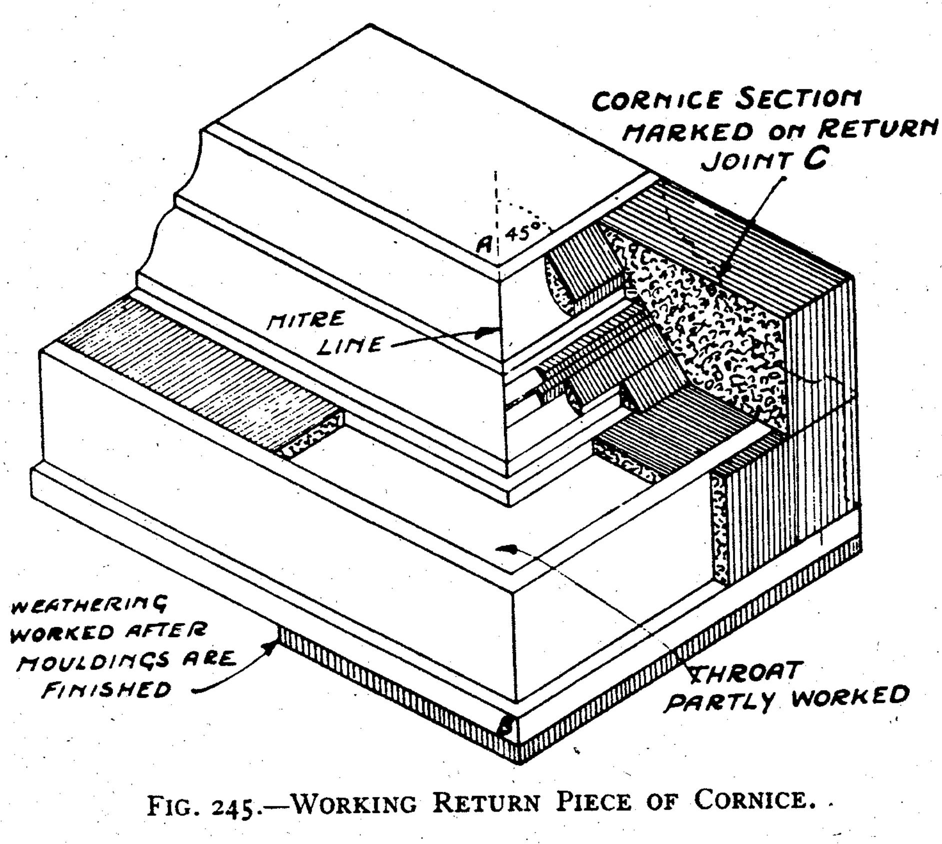

FIG. 245.—WORKING RETURN PIECE OF CORNICE.

Working the Return End for a Piece of Cornice (Fig. 245).—Assuming that the mouldings have been worked through the front of the stone, with the exception of the throating, the first operation is to mark the *zinc section* on the return joint C. Now scribe the *mitre line* from A to B, which, if drawn correctly, would give the correct outline of

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the return mouldings. To scribe this mitre line, a wide straight-edge is held in the position shown in Fig. 246, the exact angle to hold the straight-edge being determined by placing a square on the bed surface of the stone and keeping the flat surface of the straight-edge tight to the blade of the square.

If the return moulding is 90° to the face, a *mitre square*, comprising an angle of 135°, may be held on the *nosing*, and the straight-edge adjusted to it, as Fig. 247. A long pencil is then held flat on the wide surface of the straight-edge and moved whilst the point of the pencil is in contact with the stone, until the outline of the mitre is marked distinctly on the stone.

The mouldings are now worked step by step, as explained before, the *throat* and *weathering* being worked after the mouldings are completed.

To Work a "Break" in a Piece of Cornice (Fig. 246).—Mark on the *mitre line* as explained, also mark the *zinc section* of the cornice to the correct depth of the *break*. Then work the various members in stages, each stage being tested by applying the *sinking square*, as shown in the figure, the last operation being the working of the *throat* and the *weathering*.

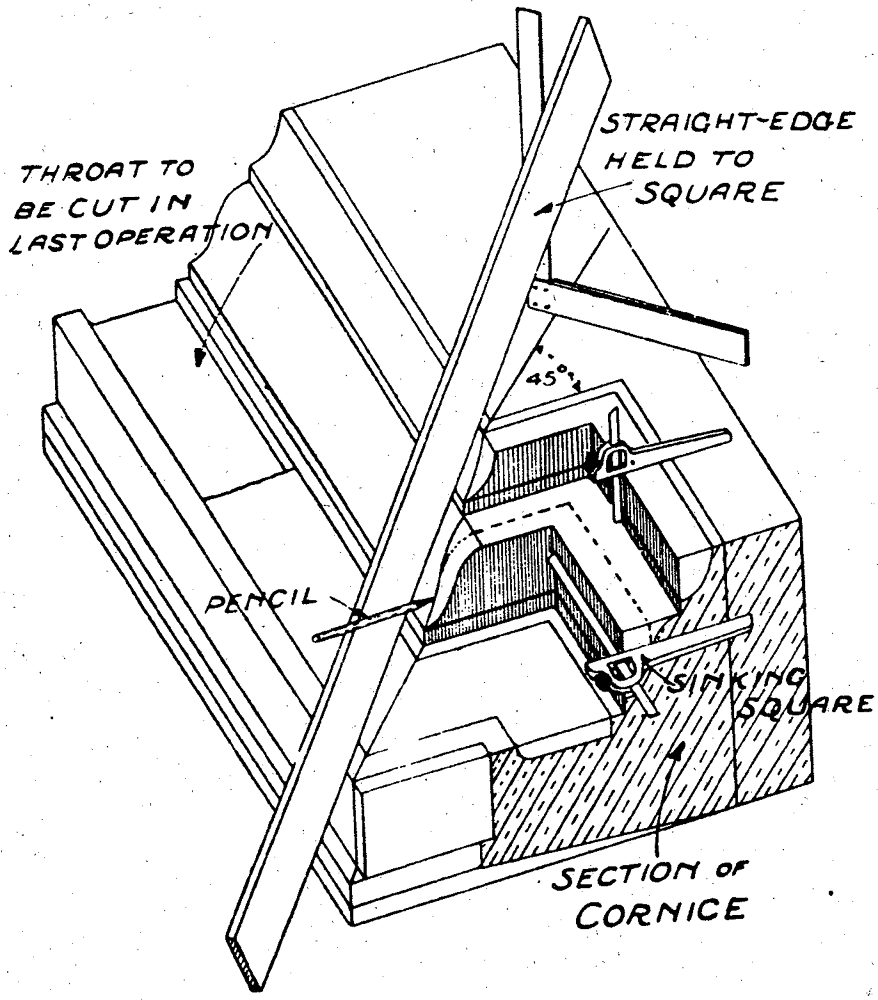
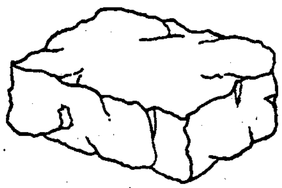


FIG. 246.—SCRIBING A MITRE LINE AND WORKING AN INTERNAL MITRE.

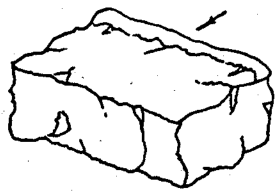
To Work a Moulded Sill (Figs. 247 and 248).—Assuming that the stone is sawn, or slabbed to height, before being bankered, first mark the *bed mould* on the top surface, and work the *nosing* along the front edge, square to the top bed. Now work the joints square from the *nosing* and the bed surface. These joint surfaces should be worked clean, back to the *wall line* to allow for the return of the moulding to the ashlar face. Mark the *zinc section* of the sill on to the joint surfaces, adjusting it flush with the *nosing* and the top bed surface. The bottom bed line and the depth of the *nosing* should now be marked on the stone from joint to joint. The moulding can now be worked in stages,

Intro. to Early American Masonry
Harley McKee

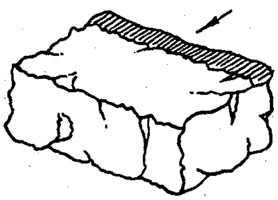
BANKERING UP A BLOCK OF STONE.



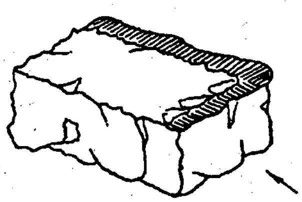
1. Roughly squared stone as delivered from quarry.



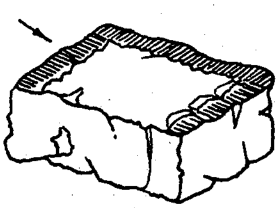
2. *The first edge is pitched off.*



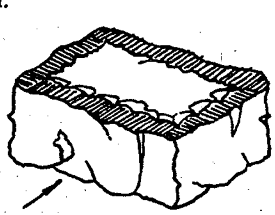
3. *The first draft is cut.*



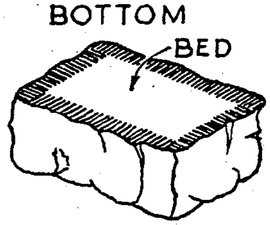
4. The second edge is pitched off and drafted.



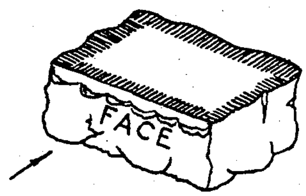
5. The third edge is pitched off and drafted.



6. The fourth edge is pitched off and drafted.

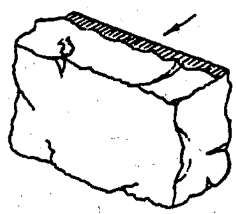


7. *The first surface is dressed.*

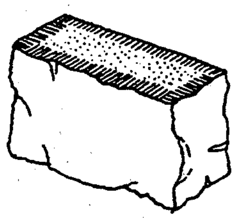


8. *The first edge of the face is pitched off.*

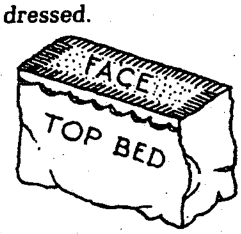
9. The block of stone is turned.



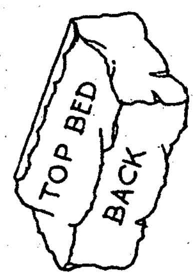
10. *The first draft of the face is cut.*



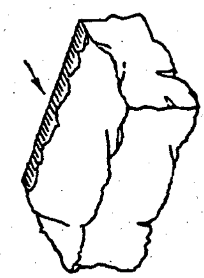
11. The other drafts are cut and the surface is dressed.



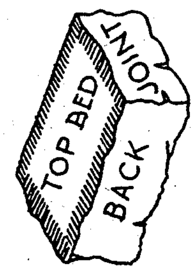
12. *The first edge of the top bed is pitched off.*



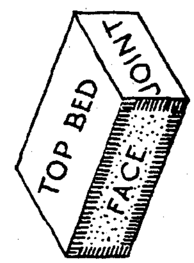
13. The block of stone is turned.



14. The first draft of the top bed is cut.



15. The other drafts are cut and the surface is dressed.



16. Similarly, the two joints and the back

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From The Stonemason's Assistant, Fred T. Hodgson

Chicago, 1913 (The 20th Century Bricklayer's and...)

ARCHES AND JOINTS

In the first part of this work, designs for many kinds of arches were given and described, and the rules given are in many cases applicable for stonework; so I will not burden this part with many examples, as those already exhibited, along with the few presented herewith, will be ample to serve the purposes of most workmen, and before proceeding further, it may not be out of place to explain a few of the terms that are made use of in connection with the construction of arches:

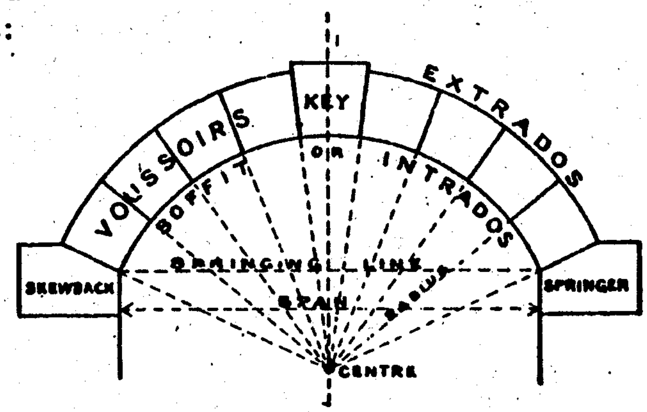

Fig. 75.

The face of the arch is the *front*, or that portion shown in elevation.

The *under surface* or *soffit* is called the *intrados*, and the outer surface the *extrados*.

The *voussoirs* are the separate arch blocks composing the arch, the central one being the *keystone*.

The *springers* are the first or bottom stones in the arch on either side, and commence with the curve of the arch.

The *skewbacks* generally apply to segmental arches, and are the stones from which an arch springs, and upon which the first arch stones are laid.

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The *span* of the arch is the extreme width between the piers or opening; and the *springing line* is that which connects the two points where the intrados meets the imposts on either side.

The *radius* is the distance between the center and the curve of the arch.

The highest point in the intrados is called the *crown*, and the height of this point above the springing is termed the rise of the arch.

The *center* is a point or points from which the arch

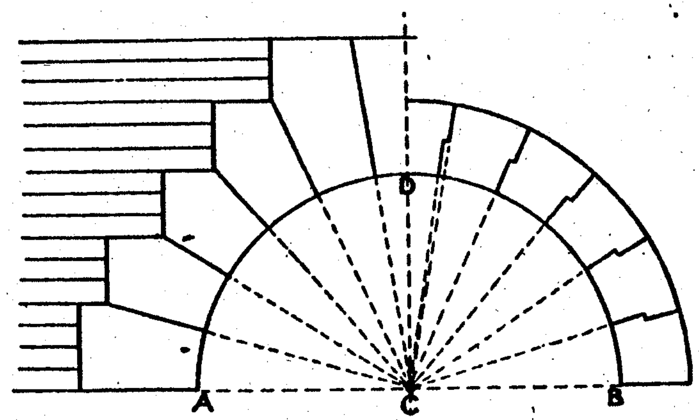

Fig. 76.

is struck; and lines drawn from this center or centers to the arch are radiating joints, and are also called *normals*.

All joints in arches should be radii of the circle, circles, or elipses forming the curve of the arch, and will therefore converge to the center or centers from which these are struck.

Fig. 75 shows a segmental arch, in which the above-mentioned terms are illustrated.

Fig. 76 is a semicircular arch, *AB* being the span and *CD* the rise; the left-hand half has the ordinary joints radiating from the center *C*, and the right-hand half,