the present time. It connects France and Italy under the Alps Mountains, and is 9¼ miles in length.

Passing from rock to earth formation in connection with tunneling, the earth formation is much more difficult to successfully tunnel. Although it might not appear so on first consideration, the blasting and removing of rock is a very simple operation in comparison to the removing of soft material, in the face of a cave-in, quick-sand and a great many other obstacles, which cannot be gone into here.

A Good Method of Blasting.—The explosives used in the blasting operation consist principally of gun-powder, nitroglycerine and dynamite. The methods used are various, but one which is used a great deal and which seems most efficient is the American centre cut method.

In this method seven or eight holes are bored in the facing in the form of a polygon, the holes tending to terminate at the point. The holes are charged and fired, extricating the conical, or pyramidal structure. Another circle of holes is forced in a cylindrical form round about this opening. These are charged and fired, and a cylindrical shaped fissure is opened. In this way the blasting operation is carried on until the opening is brought to the required size and shape.

The distinguishing feature of the method is the way in which the opening is begun. The futility of making a blast without first weakening the substance by extricating the cone section can easily be understood. When this is done, the rest of the operation may be manipulated with comparatively little difficulty.

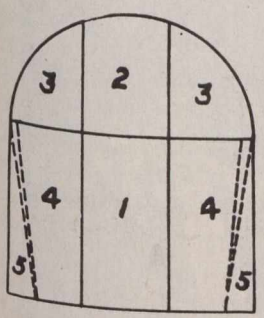

Fig. 3.

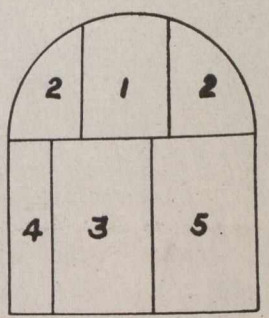

Fig. 4.

Tunneling Through Soil.—The engineers of different countries seem to have contrived methods by which every kind of loose structure may be successfully treated. In most respects the following methods are very much the same; the Belgian, English, German, Austrian and Italian differing only in the order in which the drifts and headings are excavated, and also in the different frame structure employed. The Belgian method consists of putting forward the arch before the walls are built; while in the German method the perimeter is excavated and lined before the core is removed. In types such as the English and the Austrian the whole fissure is excavated before the lining is placed, although, however, the excavation is never far in advance of the masonry work. The Italian method consists of excavating the lower half, lining it and filling it in again, followed by the work of excavating the upper half.

Submarine tunneling is perhaps the most expensive, and seems much more difficult than any of the other soft-ground tunnels, particularly in the case of tunnels which are constructed at small depths below the water bed. There is always a danger of flooding, and the materials encountered are extremely difficult to handle. Various methods are used, some of the most important being the shield method, the compressed air method, and when we come very close to river bed we use the cofferdam method, and pneumatic caissons.

The shield method is very interesting from a historical point of view. It was invented by Isambardt Brumel, a French engineer, in the early part of the 18th century. The Frenchman was gifted with a keen sense of observation. While cruising, he happened to observe the ingenious method of the ship worms in working their way into the wood. He noticed that as the animal bored its way in it applied a secretion which lined the opening and rendered the lining waterproof. Being an engineer, the idea intimated itself very strongly to his mind in connection with submarine tunneling. He immediately set to work to contrive a mechanical device which would give the same result as the boring of the small insect, and finally succeeded by inventing his universally known boring machine.

The invention consists of a circular boring disc placed immediately in front, which might be termed to represent the head of the insect, while the body is cylindrical in shape and constructed of steel in the form of a shell. In operation the earth is conveyed out and the tunnel is lined with steel tubing immediately in the wake of the boring machine. In this way it is kept perfectly water-tight, eliminating the possibility of cave-in, and making the otherwise difficult task into a comparatively simple operation.

HEWN OUT OF ROCK.

A peculiarity of the New South Wales Government dockyard on Cockatoo Island, in Sydney Harbor, is that it is hewn out of solid rock Historically, Cockatoo Island is of much interest, as it was the site of a large prison in the days when British convicts were deported to Australia. The present offices on the island are in the old prison buildings, the stone walls, barred windows, and iron-doored cells being still in evidence.

The formation of the island was originally quite unsuitable for a dockyard, as the solid rock rose sheer from the water to a height of 60 to 70 feet. By using convict labor, however, the rock was gradually cut back, first, to permit the building of graving docks, and later to make room for building slips and shops near water level. The work has been continued until at present two-thirds of the total area of thirty-three acres has been brought to a practically uniform level of about 15 feet above high tide.

When a beam of X-rays is passed through thin, rolled metal sheets to a photographic plate placed parallel to the sheet, H. B. Keene, of the University of Birmingham, finds that these patterns are of two classes, in one of which the central spot produced by the direct beam is surrounded by an irregular halo of smaller spots, while in the other the patches around the central spot are extended and form a faint but perfectly symmetrical design. The figures vary with the metal. Markings of the first kind are produced by metal sheets that are either well aged or recently annealed, and the symmetrical patterns are given by newly-rolled sheets. The spots are due to reflections from the micro-crystals within the metal; the symmetrical patterns are formed by the structure imparted to the metal by the rolling. Annealing a newly-rolled sheet changes the pattern from the second to the first class, and rolling an annealed sheet gives the reverse change.