damage from frost action. As, however, there are exceptions to this, it is desirable to submit a stone of unknown frost resistance to a freezing test (see below).

4. *Frost Resistance Test.*—The apparatus [1] used for this purpose is illustrated at B, Fig. 35. It consists of a wood box (22-in by 22-in. by 21-in. deep of 1-in. thick timber), a zinc ice container (14-in. by 14-in. by 13-in. deep of 20 Z.G.) with lid, a wrought iron specimen container (10½-in. by 10-in. by 9-in. deep of 14 S.W.G.) with cover, and a bag filled with sawdust (or similar insulating material) as a cover to the wood box.

The test is performed in the following manner: Sawdust (or granulated cork) to a depth of about 4-in. is placed at the bottom of the wood box; the ice container is placed on top of this sawdust and this or similar insulating material is packed at the sides as shown in the section; the stone specimens are placed in the specimen container, the metal cover is tightly screwed down to ensure that the rubber packed joint is watertight, and this container is placed within the ice container. The freezing mixture is then packed in the ice container, the lid is fitted on it and, finally, the sawdust bag is placed over the outer box (see section). The freezing mixture consists of 2 parts (by weight) of ice to 1 part (by weight) of common salt. This produces a temperature in the specimen container varying from 15° to 20° F. (−9° to −7° C. approx.). The specimens are subjected to this temperature for eighteen hours, after which they are removed and gradually thawed in water for six hours; after examination, they are replaced, again frozen for eighteen hours, removed, thawed for six hours and examined. This cycle is repeated until the samples have undergone ten freezings.

The specimens listed in Table V were tested in this manner. It will be seen that some were unaffected and others showed damage at the arrises. Stone of poor quality is seriously damaged when subjected to this test, some splitting and showing similar signs of disruption after only the first or second freezing.

The weather conditions experienced in this country are not sufficiently severe to cause frost damage to stonework in general walling, unless the stones are face-bedded and the stone is of inferior quality, but coping, etc., stones are liable to disintegration if subjected to prolonged periods of rain followed by frost (see p. 99).

Other tests include a chemical test (such as subjecting the specimens in a closed tank to hydrochloric acid fumes) and that for determining the compressive strength; a machine used for the latter is shown at E, Fig. 9, and described on p. 32.

QUARRYING AND MINING

A description of quarrying appears on pp. 33 and 34, Vol. I. Open quarrying is not resorted to when building stone is at a considerable depth below the surface, as the removal of the overburden would be too costly. Beer stone and most of the limestones (including Congrit, Corsham Down, Monk's Park and St. Aldhelm Box Ground, see Table VI) obtained in the Bath district are mined. A typical stone mine consists of an adit or tunnelled opening made in the side of a hill at the level of the best stone. The adit is continued as the stone is removed and follows the bed. Branch tunnels are formed from this main gallery. In the Box Ground mine the underground workings pass from one side of the hill to the other, a distance of three miles, and the galleries in some places are nearly 100 ft. below the surface. The height of the tunnels is at least equal to the thickness of the good stone beds, which may be up to 10-ft., and the width may exceed this.

The roof and floor of a tunnel consist of hard coarse stone. The first operation in winning the limestone is to pick out the top 9-in. of the stone just below the roof; this is called the *picking bed*, and the tool used is a long-handled pick. When the picking has proceeded some 5 or 6-ft., a long hand saw is employed (which is operated at the handle by both hands) to divide the rock by vertical cuts extending from the top to the next bed and at about 5-ft. horizontal intervals; this operation is comparatively easy as the stone is very soft. A block, having three free sides, is removed either with large crow bars or by a crane, the rope from the latter being attached to a lewis bolt inserted in the face of the block. The blocks, which may weigh from 6 to 8-tons, are squared up with saws, and then lifted by the crane on to bogies which run on lines and are horse-drawn along the tunnel to the surface depot. The roof is supported at intervals by strong cross-beams supported by props at the sides; falls of the roof are also averted by the insertion of oak wedges in any vertical cracks or vents.

When Bath stone has just been removed it contains much quarry sap; it is soft, and if used immediately it would weather badly. It is therefore allowed to *season* for a period before being fixed. The time allowed for the blocks of stone to remain in the stacking ground depends very largely upon the demand, but normally the stone is seasoned for several months before being dressed. If necessary, the stone can be dressed soon after mining if obtained between the late spring to the end of September, but that mined during the winter months is stored underground till the following spring before it is worked. Damage from frost is thus prevented.

[1] As used in the Department of Building, Manchester College of Technology.

MACHINE DRESSING

A brief description of certain machines used for dressing stone is given on pp. 34 and 35, Vol. I. Some of these are illustrated here in Fig. 36.

FRAME SAW (see A and B).—This machine, which is used for sawing large blocks into several smaller slabs, has a swing frame which holds the desired number of steel saw blades. The frame is suspended by four rods, and operates with a backward and forward motion by means of a connecting rod secured to the frame and the crankshaft of the flywheel which is driven by electric or other power. The blades are either corrugated (see C) or wavy or plain in section, the former being commonly used for sandstone, limestone, slate and granite, and the plain type for marble; they are 3, 4, 5 or 6-in. wide by ⅛-in. thick (for marble), 3/16-in. thick (for sandstone and limestone) and ¼-in. thick (for granite). This machine is made in various sizes, the maximum size of stone that can be dealt with varying from 8 to 14-ft. long, 4 to 8-ft. wide and 4 to 6-ft. thick.

The block of stone to be converted is placed on a bogie or trolley, packed firmly and level, and wheeled in position under the swing frame. The required number of blades is fixed in the frame at the necessary distance apart. The maximum number of blades which may be fitted to the frame depends upon the hardness of the stone and the power of the machine; generally the number does not exceed twelve, and this may be reduced to four or five blades if the stone is very hard; for marble slabbing, when the thickness of the slabs may be only ½-in., the number of blades (which are secured by special fittings) may reach thirty. The machine is set into operation causing the saw frame to descend the long worm screws in the four legs at a predetermined speed and regulated by the ratchet arrangement controlled by the levers shown at A. The rate of the downward feed is regulated according to the hardness of the stone, the number of blades used, etc.; as a guide, the cutting speeds of one 12-ft. long machine, having twelve blades, are 5, 12 and 30-lin. in. per hour for hard