formative process. The first is the older and is still by far the most important. The second is a later ideal towards which design and practice have been extending. As yet grinding cannot compete with the work of the single-edged tools and milling cut­ters when large quantities of material have to be removed. Just as some leading firms have been designing stiffer machines having fuller lubri­cation with a view to increase the duty of grinding wheels, the advent of the high-speed steels has given a new lease of life to the single-edged cutting tools. The rivalry now lies not with the tools of carbon temper steel, But with high- speed varieties. But as a corrective process grinding never occupied so im­portant a position as it does to-day, and its utility continues to extend.

The commoner forms in which grind­ing wheels are made are shown in fig. 53. These are varied largely in dimensions, from tiny cylindrical rollers a fraction of an inch in diameter for hole grind- ing, to big wheels of 3 ft. or more in diameter. Safety mountings, two examples of which are shown in fig. 54, embody means of retaining the broken pieces of a wheel in case it bursts.

*Sand-blast.*—The well-known erosive action of sand when driven against rocks and stones by the wind is utilized industrially in the sand-blast apparatus, the invention of B. C. Tilghman. The sand, is propelled by a. current of steam or air, and being delivered through a nozzle is directed against the surface of the work, cutting it away by the action of the enormous number of grains striking the face, each removing a very minute quantity of material. The action is very gentIe, and may be modified by varying the class of sand and its velocity. Other materials, such as emery, chilled iron globules, &c., are employed for certain classes of work. In some instances the powder is used dry, in others it is mixed with water, being then in the condition of fluid mud. The plant includes an air-compressing engine, an

air reservoir and the blast nozzle through which the air passes and propels the sand in the form of a jet. The pressures range from 8 lb up to about 60 lb per sq. in., depending on the class of work which is done.

The peculiar advantage of the sandblast lies in its adaptability to the working of irreular surfaces, which could not be touched by any other class of grinding. The blast penetrates hollows and recesses, and acts over an entire surface. There are many classes of operation done with the sand-blast, including cleaning, frosting, ornamentation, engraving and sharpening. In engineers’ works a large amount of cleaning is effected upon castings, forgings, sheets and other products, either preparatory to machining or to painting, enamelling, tinning, galvanizing or plating. Cycle frames are cleaned with the sand-blast after brazing. The teeth of files are sharpened by directing a stream of sand and water against their backs, with the result that the burr thrown up by the chisel when cutting is obliterated, and a strong form of tooth is produced. Worn files may also be sharpened up to equal new ones by sand-blasting them. Frosting glass is another usefuI application of the sand-blast, and by attaching suitable patterns or designs to the surface the sand may be caused to work ornamental figurings. It is a peculiar circum­stance that the sand has little effect upon soft and yielding substances in comparison with the abrasion it produces on hard surfaces, so that the pattem will remain undamaged, while the glass or other object beneath is frosted where the sand reaches it, through the openings. Not only can designs be worked on glass, or cut in stone, but perforations may be made in glass, &c., by the continued action of the sand, without any risk of fracture occurring. Much sand­blasting is performed inside closed chambers, having panes through which the workman watches the progress of the operation. But when the blast must be used in the open, protection is necessary and is afforded to the operator by a special helmet, which keeps out the flying dust and gives a supply of pure air through a tube in a similar fashion to the diver’s helmet.

VIL—Sawing Machines

Metal-sawing machines are employed extensively in engineering works for cutting off bars, shafts, rails, girders and risers on steel castings, and for getting out curved pieces which would be difficult and expensive to slot. There are three classes of these saws, circular, band and reciprocating. The first named are used for straight­forward work, operating at right or other angles, the second for straight cuts and also for curves which can­not be treated with circular saws, and the third for small pieces. The circular saws em­body a stiff spindle, carrying the saw disk and driven by gearing. This spindle may be mounted in a sliding bearing to carry it past the work held on a fixed table, or the spindle may be sta­tionary and the work be moved along past the saw. The method of feeding should be sensitive, so that it will “ give ” and prevent damage