dropped upon it, and the parallelogram *R ρ p σ com*pleted, we shall have the diagonal force *p* R resolved into It σ and R ρ ; whereof R ρ alone tends to turn round the crank, R σ producing only pressure towards the centre. In this case the angle ***ρRσ*** is equal to the two interior angles of the triangle *p* R O, that is to ω + θ, the sum of the angles of the connecting-rod and crank with the line of the piston. Hence the whole force in the connecting-rod becomes resolved into *p* H. cos. (ω + θ*)* and the whole force of the steam on the piston-rod becomes on the extremity of the crank F.cos.(ω+θ)./sin.θ.

*The Piston*—The next elementary part of the steam engine, upon which much of the efficiency of its operation depends, is the piston. Pistons were at first very rude implements for steam to work with. A large block of wood cut round to fit the inside of the cylinder, and driven very tight so as pretty nearly to fill up the cylinder, was considered a sufficient obstacle to resist the passage of the steam, until it had performed its duty, either of driving the piston from the bottom to the top, or from the top to the bottom of the cylinder. It next became usual to cover this piston with leather ; but the heat **of** the steam soon dried up the leather, and deprived it of the requisite pliability. The next step was to make the piston of metal, like the piston of Otto Guericke’s atmospheric engine, and then to make a groove around this piston, which was filled with bands of plaited hemp, now technically called a gaskin, so put together as to be spongy and elastic, and to interpose this elastic sub stance between the piston and cylinder, so that the hemp, yielding to the inequalities of the cylinder, should fill them up without permitting the steam to escape. This has been successfully used for a long period, and, where the cylinder is in good condition, used with ad vantage : and it is still very extensively employed. In stead of using a solid piston with a groove for the hempen packing, it was found better in practice to contruct the piston as shown in fig. 182. The lower part of the piston is formed of a plate attached to the piston-rod ; the under edge of this plate is of a diameter a little less than that of the cylinder, and it gradually curves inwards, so as to form the lower portion of a groove for the packing. The upper part of the piston consists of a plate with a similarly curved rim, completing the groove. This

upper plate is called the piston-cover, and is attached to the lower plate or body of the piston by screws. In the groove are carried round bands of soft plaited hemp or gaskin, which fill up the cavity ; and as the gaskin wears, the upper plate is screwed closer to the lower one, and

forces the packing against the sides of the cylinder. The piston is represented *in situ* in figure 184.

The only fault of this hempen packing is its liability to wear out, and become rigid and unelastic. A plan was next adopted of protecting this hemp, and still using its elasticity. Around the piston, in front of the packing and enveloping it, two brass hoops, fig. 186, with slits in them, were placed, to protect it from contact with the cylinder. These slits allowed the hoops to enlarge and contract their diameter, in correspondence with the ine qualities of the cylinder; while by the elasticity of the hemp, they were kept continually pressed out in contact with the surface. This simple metallic packing is re presented as applied to the piston in figure 185.

A still more independent metallic packing is produced in the following manner, so as to dispense altogether with the elastic action of the hemp. Large metallic belts of considerable thickness are cast, so as to form solid rings, about a hundredth part greater in diameter than the inside of the cylinder they are to fit, and turned on a lathe truly cylindrical to that diameter. A small portion is then cut out of the circumference of each ring, so as to make them open hoops like those represented in the last figure; and the two open ends are then forcibly brought together, until their diameter is just such as to admit them into the cylinder, their ends being now in contact so as to form complete rings, and they are again placed in the lathe and turned truly cylindrical. By this arrangement it is brought about, that the elasticity of the rings continually urges them outwards, towards their original diameter, and so dispenses with the elasticity of the hemp, forming a packing wholly metallic. This is employed on a large scale by some of the very best engineers in this country, and is greatly to be recommended for its simplicity. Of course the break in the ring would allow steam to pass; but this is avoided either by interposing a metallic tongue at the break, or by using a number of rings, so that the break in one of them may be opposite to the sound portion of the other.

Another form of piston may be called the wedge metallic piston. The rings are cut into a number of parts, and are pressed upon the cylinder by wedges, which again are kept in their places by springe ; and so it is supposed that a more perfect adaptation is gained of the parts of the ring to the cylinder. This is certainly the case ; but the ring is much more complex than in the other form ;—

In fig. 187, wedges are shown to be inserted behind the rings, with springs behind them, forcing them out wards; and in the figure 188, a single elastic hoop is substituted for all those springs. Springs without wedges