*Outer Cover.—*The outer cover has to be strong enough to with­stand the air-pressure inside the tire and to transmit the driving or the braking effort from the wheel to the road surface. For the latter purpose, the threads of the fabric are best disposed spirally, as shown in fig. 6. While driving in the direction of the arrow the tension on the fibres *cc* will be slightly increased, that on fibres *dd* decreased. The distortion of the fabric due to driving is thus reduced to a minimum. A woven fabric is sometimes used, but one made up of two or more layers of parallel threads embedded in rubber is better. This construction makes the outer cover more flexible, and consequently less energy is wasted in distorting the fabric as the tire rolls on and off the ground, while greater durability is also secured. Fig. 7 shows a plain woven fabric, from which it is seen that each thread takes the form of a sinuous line. As the air-pressure inside the tire is increased the threads tend to become straighter, thus pressing together with a cutting action. The total thickness is greater than that of two layers of parallel threads, while on the latter the threads can be placed closer together. The woven fabric is therefore stiffer, weaker and less durable than that built up *of* parallel layers. The average tensile stress per inch width, *t1*, on the longitudinal section of the cover is given by the formula *pd = 2t1∙,* that on the transverse section, *t2*, by *pd* = 4*t2*, *d* being the diameter of the tire in transverse section; consequently the stress on the longitudinal section is twice that on the transverse. With the spiral disposition of the threads, as shown in fig. 6, this inequality of stress in the two principal direc­tions has the effect of tending to enlarge the transverse section of the tire, while at the same time tending to contract the tire on the rim.

*Single tube, Double tube and Tubeless Tires.*—A tire, beside being strong enough to resist the stresses to which it is subjected, must be air-tight. In most tires for cycles and motor-cars an inner tube of india-rubber is made separate from the outer cover. In these double­tube tires the outer cover is more or less easily detachable from the rim. The air under pressure is pumped inside the inner tube, which is sup­ported by the outer cover. In case of puncture of a bicycle tire, the inner tube is repaired by cementing a patch of rubber on the outside of the inner tube, a solution of india-rubber in naphtha or bisulphide of carbon being the cementing agent employed. Motor-car tires are best re­paired by vulcanizing, as solution patches usually come loose owing to the heating of the tire. In a single-tube tire, as its name indicates, the outer cover and the air-tight tube are vulcanized together to form a single hollow ring. To repair a simple puncture of a single-tube tire it is not necessary to detach it from the rim. Single-tube tires are not often used now, except for path-racing bicycles. A tubeless tire, such as the “ Fleuss ” (fig. 8), consists of the outer cover, as used in a double-tube tire, to the inner surface of which an air-tight layer of sheet-rubber has been cemented. A continuous flap projects from one edge of the tire, and when in position on the rim this flap is pressed against the other edge, forming an air-tight seal. A slight moistening of the flap with soft soap tends to remove any imperfection in the tightness of the air. seal. The repair of a puncture of a tubeless tire can be very quickly done. Since the inner surface of the air­tight layer is accessible, after placing the patch in position the tire can be inflated and the bicycle ridden at once ; whereas in the double­tube tire sufficient time must elapse between the patching and the inflation to allow the rubber solution to set.

*Attachment of Tires to Rims.—*A single-tube tire can be cemented directly to the rim. For detachable double-tube tires on bicycles, two methods, the Dunlop-Welch endless wire (fig. 9) and the “beaded edge” (fig. 11), account for by far the greater proportion. In the Dunlop-Welch tire the endless wires are embedded in the two edges of the outer cover respectively, the transverse tension of the fabric being transmitted to them. Each endless wire is. formed of three coils, so as to give flexibility to the edge of the cover. The ring formed by each endless wire is smaller in diameter than the edge of the rim. The middle portion of the rim is deepened, its diameter being less than that of the ring of endless wire. To detach the tire after deflation, one part of the edge of the outer cover is depressed into the bottom of the rim, the opposite part then projects slightly beyond the edge of the rim and is pulled outside; one portion being got outside, the rest easily follows. Fig. 10 shows the nature of the mutual action between outer cover *C,* rim *R,* and endless wire *W* in a Dunlop-Welch tire. The transverse tension *T* on the outer cover is transmitted to the endless wire *W,* which is also subjected to the reaction *N* of the rim. The resultant *Q* must lie in the plane of the endless wire *W,* and constitutes a radially outward force acting at all points, which in turn causes a longitudinal pull, *P,* on the wire. Let *d* be the diameter of the inner air-tube, *D* the diameter of the ring formed by the endless wire *W, p* the air pressure, and *0* the angle between *T* and *Q.* Then for each inch length of wire *T=pd∣2, Q=T∣cos* 0; while *P = QD∣2.* Combining these results, we get *P = pdD∣4* cos θ. If θ =30°, P=0.29*pdD,* from which the section of wire for a tire of any size can be calculated.

In the "beaded edge ” fastening, thickened edges on the outer cover take into corresponding edges formed on the rim, and are securely held therein when the tire is inflated.

*Prevention of Punctures.*—The outside of the tire is covered with a thick layer of rubber, which protects the fabric from injury by contact with the rough road surfaces. In full roadster tires this outer layer of rubber is thinner at the sides than at the tread (the part which actually rolls on the ground), but still completely covers the fabric. In light roadster and racing tires the sides are not covered, and an appreciable gain in speed or ease of driving is due to the greater flexibility of the cover thus obtained. Numerous puncture-proof bands and other devices have been tried with the object of absolutely preventing punctures, or making the tire self­sealing after puncture; but they increase the rolling resistance, and therefore the effort necessary to drive the bicycle at a given speed.

*Valve for Pneumatic Tire.—*A non-return valve is permanently attached to the inner tube of the tire, which allows the air forced from the inflater to pass inside the inner tube. The most commonly used, the Dunlop-Woods valve, consists of a short piece of rubber tubing mounted on a brass stem, which has a small hole communi­cating from its outer end to the inner surface of the rubber tube. Normally, the tubing closes the mouth of this hole, preventing the air from escaping from the tire, but lifts freely when air is being forced from the inflater. The arrangement of the parts for deflating and for getting access to the rubber tubing is very simple and effective. The cyclist should be careful that the small piece of valve tubing, and the two fibre washers at the ends of the flexible connecter which serve to make air-tight the two joints between the latter and the pump and valve stem respectively, are always in good condition. If either of these seemingly small details is out of order it may be impossible to pump the tires hard enough ; the bicycle being ridden, the tires may be nipped in many places between the rim and sharp edges on the road surface, and practically ruined.

*Tires for Motor Cars.—*In the cost of upkeep of a motor car the tires are the most expensive item. For a slow speed vehicle an ordinary steel tire, shrunk or hydraulically pressed on a wooden wheel, is cheap and durable. At higher speeds over uneven roads it is less satisfactory; the wheel, forming with the tire one rigid body, receives violent accelerations vertically, due to the uneven road, and is being continually shot upwards into the air out of contact with the ground. Thus excessive noise and vibration are caused at all but very moderate speeds, and for passenger cars an elastic tire is a necessity. The solid rubber tire, not being liable to puncture, is trustworthy if made of sufficient sectional area, but it is expensive and lacks the comfort and easy running of the pneumatic. The motor car pneumatic tire is made on the same lines as the cycle tire, but the air-tube is thicker, and the outer *cover* is built up with several layers of canvas or fabric to give the necessary strength (fig. 14). To provide for wear, the outer protective layer of rubber is considerably thickened at the tread, where it is also reinforced with two or three layers of canvas. The Palmer cord tire is built up of two layers of cord (fig. 12) arranged spirally, each cord being composed of four strands of six threads. The cords are flattened