pounds to the square inch, the range of pressure, even in a multi-cylinder petrol engine, is comparatively limited.

Why a Change-Speed Gear is Needed.

It is true that this mean pressure can be reduced by throttling (at the expense of economy), and that it is somewhat increased when the engine is running slowly with a heavy load and the throttle full open; but the useful range of pressure is certainly fifty per cent. less than in the case of the steam engine with boiler pressure at 200 pounds. For this reason, it is essential for the petrol engine to maintain a certain speed in order to develop its maximum power; and to effect this, and at the same time make it possible for the tractive force to be varied, the change-speed gear is introduced between the engine and the wheels.

To overcome the inertia of the car and accelerate its motion from rest, it is usual, and in most cases necessary, to start on the low gear, and this is because the maximum available tractive force is required. As soon as the vehicle is in motion, and has begun to store kinetic energy, a less tractive force is sufficient to propel the car with increasing velocity, and so the other gears are passed through in succession until the top gear is reached. But whatever gear the car is working on, the work done in unit time or power developed is the same, provided the engine runs at a practically constant number of revolutions per minute and the throttle remains unaltered.

Tractive Force Available.

The maximum tractive force available at the surface of the driving tyres of a 20 h.p. four-cylinder car is about 14 cwts., when on its lowest gear, assuming 20 as the limit of power the engine is capable of developing. On its top gear, this force would measure about 4 cwts., but the figure, of course, depends upon the ratio of the gears.

The practice of starting a multi-cylinder car from rest with a full load, on the top gear, is to treat the engine with little consideration. The tractive force available would only be one-sixth of that available on the low gear, as it would be necessary to run the engine at far below its normal speed at the time of letting in the clutch.

In summing up the foregoing remarks, it may be stated that the petrol automobile, like the railroad locomotive, varies its tractive effort from a maximum when starting with full load and ascending inclines, to a minimum when travelling its fastest on the level; but, unlike the locomotive, the horse power developed by its engine remains practically constant under varying conditions of car speed and road surface.

Strengths of Shafts and Axles.

Shafts and axles used in the construction of petrol cars are not designed entirely with reference to the horse power they have to transmit. For instance, the crankshaft of a 20 h.p. four-cylinder engine does not require to be larger diameter than that of a 10 h.p. two-cylinder engine, because the maximum twisting moment to which the former shaft is subjected is no greater than that transmitted by the 10 h.p. shaft.

The twisting moment to which a shaft is subjected and is called upon to transmit is measured by the product of the tangential force in pounds weight and the distance in inches from the centre of the shaft at which the force acts. It is therefore measured in inch pounds, and represents work done when in action.

A little consideration will show that the 10 h.p. shaft receives two impulses during two revolutions, while the 20 h.p. shaft receives four impulses during a like period; but the measure of each impulse in both cases may be approximately equal, the difference being that in the case of the 20 h.p. shaft the impulses are more frequent.

The discussion of twisting moments with reference to the transmission gear of automobiles suggests the consideration of the effects of different sized sprockets for chain-driven cars.

Effect of Changing Gear Ratios.

It frequently happens that the owner of a petrol car desires to fit slightly larger sprockets to his differential shaft, as he is anxious to increase the speed of the car on all gears, or, at any rate to reduce the revolutions of the engine for given speeds of the vehicle itself.

When this alteration is effected, it is well to remember that the whole transmission system is subjected, under ordinary working conditions, to greater twisting moments on all gears.

To illustrate this fact let us suppose that a car is capable of ascending a long incline (with full load of passengers) on the second gear, and that the engine is developing maximum power at 1,200 revolutions per minute

The same car is afterwards fitted with larger sprockets, and on ascending the same incline under exactly similar conditions it is found that the engine speed is reduced to 900 revolutions per minute, and that the speed of the car itself is the same as before. This, of course, means that the power developed and transmitted to the road wheels is the same as in the first instance, and, since the revolutions of the engine have decreased, the mean pressure on the pistons must have increased, otherwise the power developed would be less. This increase in pressure would be a natural result, owing to greater compression at lower engine speeds.

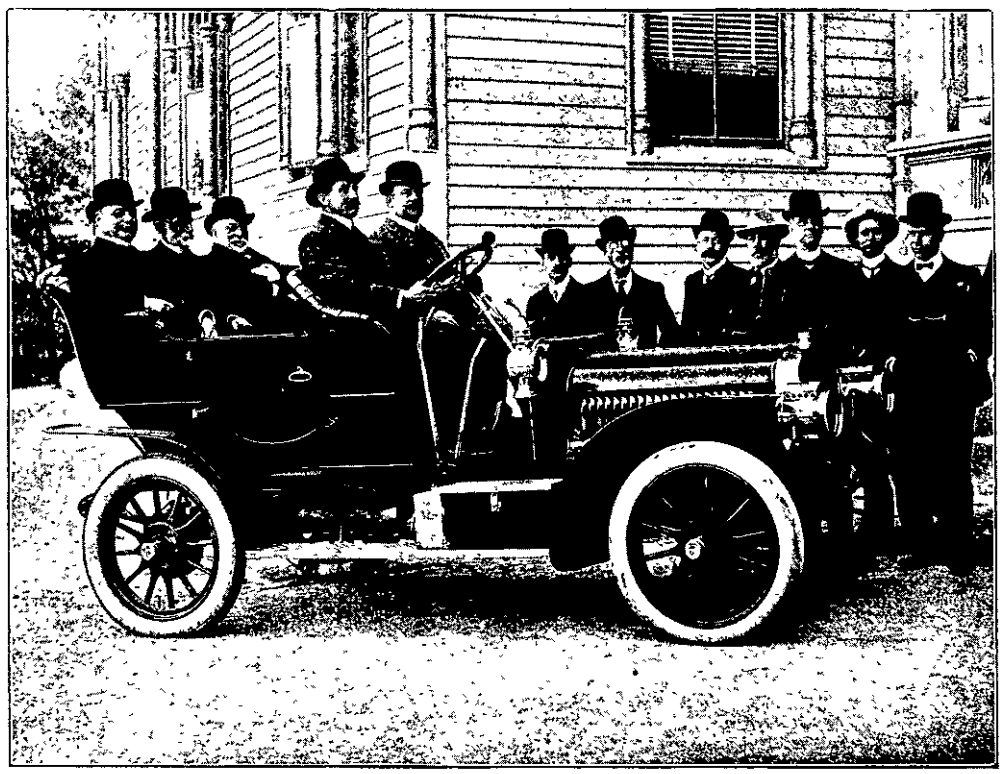
And so it follows that the twisting moment transmitted by the crankshaft and gears to the differential case and shaft is augmented, although the power transmitted remains the same

If the problem is approached from the other end of the transmission system, it will be seen that the pull on the chains in pounds weight is the same as when the smaller sprockets are in use; and as this pull is acting on the differential shaft at a longer radius (with the large sprockets), the twisting moment to which the shaft is subjected must be greater

It may be urged that the car will travel slower in the second instance when ascending the incline, and the engine speed be reduced to 750 revolutions, which means that less power will be transmitted until the driver changes down to the first gear; but the tendency under these circumstances is for the driver to keep the ignition hard up to its work and obtain all the power out of the engine that he can before changing down

But, in any case, the fact remains that the actual torsional stresses to which the transmission system is subjected are greater for given speeds of the car than when the smaller sprockets were in use, and it is more than likely that trouble will result unless due care is taken to change down earlier than formerly.

Unless a motorist uses his car in an essentially flat district, he is wise to retain the sprockets originally fitted by the makers.—John O. Crombie, in *Autocar*.



30-H P 4-CYLINDER CADILLAC TOURING CAR, WITH THE PREMIER (SIR J G. WARD) AND PARTY.

Useful Hints.

By "Accumulator"

Unless the brakes are water-cooled, care must be taken that they are used alternately on a long hill, otherwise they are likely to fire and become useless

Before trying to fit new piston rings make sure they will enter the cylinder

Great care should be taken that no grease or oil be allowed to get on the tyres as it will cause the rubber to perish

Should the front tyres show abnormal wear, the front wheels should be looked to, as possibly they are out of alignment Shortening or lengthening the tie rods may be necessary

The best place to store petrol is in a metal drum underground, it takes up no valuable space, and is quite safe from fire.

The universal joint of the cardan shaft should have a protection of some sort to keep it quite clean and properly lubricated. A good plan is to cover it with a glove of pliant leather of ample size. First thoroughly wash the joint with paraffin, then cover thickly with grease, then put the glove on. A suitable glove can be made by a handy chauffeur or any saddler.

The best water to put in tank and radiator is filtered rain-water. Many cases of overheating can be traced to the deposit of mineral matter from hard water.

Should a grease pipe require cleaning out, the best way is to push a stiff wire down the pipe. After making a path through it, lay the pipe in petrol till all the grease is dissolved. Warming it over a flame effects the same purpose.

The tyre valve should always have a cap on, otherwise grit may get in, and this will be nearly certain to cause a leakage. If a cap is lost when on the road, a piece of rag should be tied over the valve and well secured.

To test a valve for a leak, turn the wheel so that the valve is at the top, then place the valve in a glass of water.

Should it be thought that the back-wheel tyres are wearing too quickly, the cause may be attributed to using the brake too harshly. When approaching traffic, or a corner, take the clutch out in plenty of time and apply brakes gently.

Occasionally drench the cylinders with paraffin; it will free the piston rings and improve the compression. This is best done when the engine is warm.

To learn to change gears properly is the ambition of all motorists, and a very good way of obtaining practice is to lift the back axle so that the back wheels are some two inches from the ground. This must be done very carefully, so that there may be no risk of the car jumping down; then, if the engine is started and throttled down a fair amount of practice can be obtained.

A car should always be kept perfectly clean, the body work should always be washed before it is put away. The engine should be cleaned externally with paraffin and a stiff brush.

The exhaust pipe should be looked at if any overheating occurs that cannot be located. A stone may have been thrown up and made a dent and this causes back pressure.

Always keep a fair quantity of French chalk between the cover and the tube; it acts as a lubricant and so saves friction and consequent heat and wear. If too much chalk is used it is liable to form into hard lumps on the cover and to increase friction thereby.

To clean out the radiators and pipes thoroughly, empty out the water, and fill with boiling water and a little washing soda; this will be found to remove scale and grease if it is left in for a few hours.