HOW TO OVERHAUL A CAR.

BY HERBERT L. TOWLE.

In order of importance, the facilities needed for overhauling are a warm, light place to work, an extension electric light, a bench, several boxes for use as receptacles and supports for the dismantled parts, and as liberal an assortment of tools as the owner's means will permit. An iron vise, a bench drill, a foot or power lathe for metal work, and an emery wheel are almost necessary. Failing these, certain parts can be sent to the shop for refitting. A complete kit of bench tools is assumed—hammers, files, hack saw, chisels, wrenchs, screwdrivers, cotter pin extractor, etc.; also a soldering torch.

The first step after washing the car is to strip it of lamps, mud guards, and small gear generally. If the screws and nuts are greasy drop them into a pan of kerosene. Have a large box handy for small parts, and three or four small boxes in it for the purpose of grouping related small parts together. It is very easy to get a car apart and shuffle the various bolts, washers, and other small things so thoroughly that it is impossible to tell where they belong on reassembling.

Ascertain by looking underneath whether the gasoline tank is attached to the body or to the chassis. If the former, disconnect the gasoline pipe at both ends, plug the ends with bits of rag, disconnect the horn tube and any electric wiring that may run from the body to the chassis, take out the bolts holding the body to the side and rear frame members, and lift the body straight up. The dash is a part of the chassis, not of the body, and does not need to be disturbed at this stage. Have a couple of wood horses ready to receive the body. Do not set it on the floor, as there may be parts projecting beneath it such as the gasoline connection beneath the tank.

The amateur is advised to begin overhauling in the order of ease rather than of magnitude. For this reason the brakes are suggested as a start. In closed rear brakes on a car with side chains are generally exposed by taking off the rear wheels. First see if the brake drums have removable cover plates. If not, take off the sprocket chains, unscrew the hub caps and nuts, and the rear wheels will come off, leaving the expanding brake shoes in place and exposed. Note whether or not the adjustment is near its limit. If so, replace the shoes. The foot brakes are adjusted or relined in the same way.

Remove the radiator, wash it out under a strong stream of water, and if it is suspected of being encrusted with scale fill it up with kerosene and let it stand—until spring time will do no harm. When re-assembling it is important to give the radiator an even bearing around all four studs, supposing it to be held down by that number. If possible, have it rest on $\frac{1}{8}$ -inch sheets of rubber, and do not draw the holding-down bolts entirely tight. The radiator, although frail, is much more rigid than the frame, and any springing of the latter will surely start leaks in the radiator if it has to follow it. The two sketches, Figs.

1 and 2, show how a frame may be racked in going over a rough road. If the radiator leaks it is best to let an expert tinsmith repair it (not all tinsmiths are expert). The secret of success is to use a good grade of solder and sweat it thoroughly into the seams, taking plenty of time. If the top is not steadied it will be worth while to run a brace or stay rod to it from the top of the engine or the dashboard. This rod need be only heavy enough to check the vibration.

If there is much lost motion in the worm or other reducing gear of the steering mechanism, disconnect the steering links, also the throttle and spark con-

nections, and take the steering column out with the reducing gear at its base. Open the casing and see where the lost motion is. It may be in the threads of the worm *A*, Fig. 3, and the teeth of the segment *B*. Much of it, however, is likely to be in the thrust washers *C C* of the steering column, and *D* of the segment shaft. Frequently ball bearings are used at *C C*. In time either these or plain washers need replacement, likewise the bushings *E E*. If the steering gear case is not provided with a grease cup, this is an excellent time to put one in. Wear on the worm and segment *A B* is

not easy to take up; an approximate cure is to make the bushings *E* eccentric, so that by turning them the centers of the worm and segment are brought closer together. Since, however, most of the wear is in the middle teeth, the gear may be loose in the middle position and tight when the wheels are cramped over. There is no remedy for this, save renewal.

The steering knuckle pivots and the pins in the ends of the cross link wear loose in time, and usually it is a shop job to ream the holes and fit new case-hardened pins. See that the front wheels are parallel or "toe in" very slightly when pointing ahead. It is usual to shape the steering knuckles so that the wheels incline toward each other at the ground. They are rarely vertical, and never incline the other way. If the front axle is sprung, have a blacksmith straighten it.

Clean out gear case and test all the bushings, including the pilot bushing at the front end of the squared shaft, by shaking them. If ball or roller bearings are used, replace them if loose; if plain bushings, they must be refitted or replaced. New bushings bought from stock generally need considerable fitting. The re-

SOME PARTS OF A CAR WHICH MUST BE CAREFULLY CONSIDERED IN OVERHAULING.

HOW PARTS WEAR IN AN AUTOMOBILE.

HOW TO OVERHAUL A CAR.

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son for this is that the shafts, especially gear shafts, wear down and must be ground true; and no manufacturers seem to appreciate the usefulness of boring repair bushings slightly under size. The pilot bushing, being solid, must be specially made to suit the shaft. Aside from this one, a skillful amateur can make a good job of scraping his own bushings if he has a suitable set of scrapers and time and patience. Red lead is used to test the fit. Of course the gear case must come out of the car, and at intervals the bushing caps are bolted down tight and the shaft turned to determine whether it is tight or free, and whether it makes contact all over.

In refitting gear shafts and bushings it is necessary not only to achieve a proper fit, but to keep the shafts absolutely parallel. If they are not, the gear teeth will not bear squarely across their face, but will wear away at their corners, as exaggerated in the dotted portions, Fig. 4.

In the matter of gear replacements the best result is naturally gained by replacing both mating gears if either is badly worn, since otherwise the new gear would have to run against a bad profile and would wear away sooner. If the car has side chain drive, the differential shaft bushings will need refitting at the same time. The parts of a differential which wear fastest are the bushings A of the spur or bevel pinions B (Fig. 5), since these are the hardest things to lubricate. To take the differential apart it may be necessary to file the ends of headed-over through-bolts holding it together. In that case the nuts should be reduced in thickness so that the bolts can be headed over again on reassembling. (The bolts in Fig. 5 do not go through.) It is very important not to give anything about the differential the slightest chance of working loose, and the same applies to the bolts holding the change gears. Another point that is difficult to oil, and therefore liable to cut, is the bearing C between the differential or gear hub and the sleeve into which the hub of the differential shell extends. This sleeve runs in plain or ball bearings in the case, with the shaft or gear hub turning inside of it whenever the car goes around a turn. Sooner or later new bushings are needed.

If oil is used in the gear case, as it must be if plain bushings are used instead of ball bearings, it becomes something of a problem to lubricate the bearings effectively without excessive leakage of oil. The writer solders a thin wire gauze screen (Fig. 6) over the interior oil pockets to exclude steel grit worn from the gears. In order to prevent escape of oil from the ends of the bushings a felt ring is necessary (Fig. 6). This ring would cause the oil near it to become stagnant were it not for a special oil groove B, which should be chipped entirely around the bushing and connect with a groove C by which oil entering it may return to the interior of the case. But for this provision particles of dirt getting into the end of the bearing would accumulate and cut the shaft.

In the rear axle of a shaft-driven car the thing most likely to need replacement is the differential. There are various ways of getting at it, depending on the design of the axle casing. If the axle is divided vertically in the fore and aft central plane, the rear springs must be jacked up and disconnected from the axle, and the halves of the axle drawn asunder after taking off the wheels. A better arrangement is to have a removable cover plate on the casing through which the differential is inserted and withdrawn. This is found especially in axles of the floating type, with wheels running on ball or roller bearings on the ends of the axle tubes and driven by "floating" shafts extending from the differential to jaw clutch plates engaging the outer ends of the wheel hubs. To remove the differential, the hub caps are first removed

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and the floating shafts slipped out from the differential without jacking up; then the straps holding down the differential are removed, the bevel driving pinion withdrawn, and the differential lifted out.

Unless a car is more than one year old it is not necessary to assume that the differential needs overhauling. By jacking up one rear wheel and rocking it back and forth, the total amount of slack in the differential may be estimated. It is also usually possible to reach the pinions through openings in the differential shell, and by shaking them to determine whether they are loose. If so, they should be rebushed and the pins or spider replaced if worn. Frequently means are provided for advancing slightly the driving pinion or gear or both to compensate for wear. If this adjustment is disturbed the gears should be moved in a straight line and not canted around; else the teeth will engage only at their small or large ends instead of over their full length. By rubbing red lead on the teeth and turning the gears, one can tell where the teeth touch.

If cup and cone ball bearings are used, whether in the rear axle or in the transmission, any worn parts should be renewed immediately. Fig. 7 shows the effect of wear on a stationary ball cone, e. g., on an axle spindle. The pressure comes against the stationary bottom portion, and, while the cup wears a true path, the cone is destroyed. It is possible, though not always worth while, to prolong the life of the cone by giving it a quarter or half turn on the shaft or axle. If the cup is stationary and the cone rotates, evidently the cup will be the first to wear out of round. When one ball of a set is renewed the entire set should be replaced with it.

We come now to the engine, the last and in some ways the most difficult part to overhaul. The owner is strongly advised not to attempt to refit the main crank shaft bearings, unless he has had considerable previous experience and knows exactly what to do. On the other hand it is not at all hard to regrind and readjust valves, replace worn valve lifters and their guides, and to do ordinary tinkering and adjusting with the timer, carbureter, etc. It is best not to tamper with the magneto further than to clean the interrupter and adjust the interrupter contact points if worn.

To overhaul the engine first strip it of all small gear. Take off the magneto, first marking the coupling so that it can be replaced exactly as it was, and tag the wires. Remove and tag the oil pipes, blow through them to see that they are clear, and plug them to exclude dirt. Disconnect the carbureter, remove the timer, take out the spark plugs and plug the holes with waste, remove the dust pan, take out and mark the valves; take off the water pipes, the pump, and the fan. Now take off the cylinders. If no further dismantling is contemplated, the piston heads may be scraped *in situ*, taking care that none of the carbon falls into the crank case; and the piston rings are likewise cleaned without removal if possible. If the rings are leaky, as proved by failure to hold compression when the valves are tight, new rings are put in and fitted to the locating pins, which prevent them from turning. At the same time the carbon can be scraped from the inside of the cylinder heads.

Take down the oil pan. Test the fit of the wrist pin and crank pin bearings by rocking the pistons and connecting rods on the pins. Do not confuse a rocking motion due to loose fit with end play on the pins. A certain amount of end play is always provided. A crank pin bushing is likely to wear conical (see shaded area) if the rod is offset as in Fig. 8, and if the rod is springy the bushing may wear bell mouthed at both ends. The crank pin itself will in time wear flat at the point of greatest pressure, as indicated in Fig. 9. It takes more skill than can be acquired off-hand to true it up again, but it can be done with a fine

Swiss file and calipers. It is not necessary to file clear around the unworn portion of the pin, since a slight deviation from its original axis does no harm, neither is it absolutely essential that it should have the same diameter throughout. Its new axis, however, must be absolutely parallel to the shaft. It is best to throw away worn bushings and put in new, taking out or inserting shims till a fit is obtained, and scraping no more than is necessary. A worn wrist pin bushing must be renewed, and usually the wrist pin must be ground true. If the crank pins are oiled through passages drilled in the crank shaft, their lubrication is probably perfect. If, however, they are oiled solely by splash and the oil holes are in the upper half of the crank pin bushing, a considerable improvement can be made by replacing the upper bushings with solid ones and introducing the oil through the bottom half by brazing a copper tube in the cap to act as an oil scoop (Fig. 10). The bottom half is then drilled and provided with an oil groove for about half its length. It is a principle of lubrication that the oil should always be introduced at the unloaded side of the journal, and that any breaks in the continuity of the loaded surface merely afford the oil an avenue of escape under pressure.

To renew the clutch leather, take off the old leather and use it as a pattern. Select the new leather carefully for uniform and correct thickness, and cut it about half an inch short. The curvature should be approximately that of the old piece (Fig. 11). Locate the end and the middle holes for the rivets, counter-sinking them considerably so the rivet heads will not come flush, and soak the strip in water till it has swelled sufficiently to go in place. Use the end of a steel bar as an anvil, and put in the end and middle rivets first, holding the strip meanwhile by wire nails. The riveting must be completed before the strip dries.

AUTOMOBILE FIRE-ENGINES.

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fire engine proper. After reaching the scene of the fire the driving gear is uncoupled and the pumps are put in connection with the engines. Such fire engines of course must draw their water from a hydrant, well, or other supply. They have done splendid work in suburbs wherever fire engines of suitable power or an adequate high-pressure system can be held in reserve. The best of these machines can run to a fire with a crew of seven men at speeds up to 60 miles per hour and carry 1,000 feet of hose. The pumps deliver 700 gallons of water per minute at pressures up to 150 pounds to the square inch. The regular steam fire engine has a capacity varying from 400 gallons per minute to 1,000 gallons in the case of the largest size of machines. Such a motor fire engine usually contains two 3-gallon chemical extinguishers, and heavy suction hose for hydrant connection, fire axes, nozzle holders, large alarm bell, the usual equipment of lamps, lanterns, tools, and small scaling ladders. In the opinion of many fire engineers a suburban fire station should have two such motor engines, with possibly a steam engine in reserve. Again, steam engines may also be held at reserve stations instead of a large number of single steamers. This means considerable economy in the purchase, equipment, and maintenance of a fire house, while the increased radius of action and the speed of the motors enable efficient service to be rendered.

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