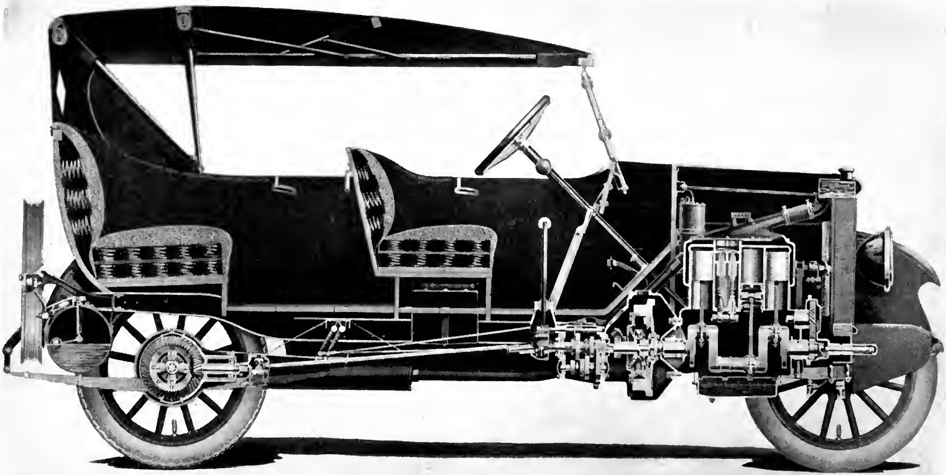
Putnam's Automobile Handbook

The Care and Management of the Modern Motor Car



Courtesy of Allen Motor Co.

SECTIONAL VIEW OF A MODERN AUTOMOBILE WITH FOUR-CYLINDER ENGINE

Putnam's Automobile Handbook

The Care and Management of the Modern Motor-Car

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FOREWORD

Much of the material, here assembled for the first time, has been printed in the automobile section of New York City newspapers. It has stood the scrutiny of the wisest men in the automobile trade and has been read eagerly by owners within the sphere of the newspapers' limited circulation; some of it has been reprinted in papers all over the country, which is evidence enough of its practical value.

The publication, however, has been without sequence and all of it has not appeared in any one paper. Moreover it has been reassembled and rewritten and much has been added to round out the story of the automobile and to adapt the material to the use of everyday men who do not understand or care for the more technical works.

It should not be taken as the last word concerning the auto. That will not be written until after the automobile has been driven out of business by the airplane or something else and is as obsolete as the oxcart of a century or two ago. There is nothing new in the principle of the gas engine, but new appliances and new methods are constantly being invented and discovered.

All that is herein contained is the result of years of experience at the Automobile School of the West Side Young Men's Christian Association, New York City. This was one of the pioneer schools and for fourteen years has turned out more than 1000 trained drivers each year who know their engine and working parts thoroughly. Last year the number was nearly 2500. Naturally in handling these thousands of bright men the instructors were stimulated and themselves learned as they taught. The consensus of this ripe experience is given here.

Lest there be misunderstanding, it were better said at once that if the reader has come to this book to learn how to be a garage mechanic, how to qualify as an expert in automotive technique, or how to learn common sense, he should at once seek another source of information. This book makes no pretensions of teaching the last word in automobile repair. But if the automobile owner desires to have a working knowledge of his car, to know how to find and overcome the ordinary ills and troubles to which it is subject, and how to diagnose and prescribe for it when it begins to wheeze or squeak or groan or knock, let him read on. The book is for him.

In other words this is not a *sine qua non*, but a friend in need; it is not a know-it-all, but a first-aid treatise. It is a leaf—several in fact—from the book of experience, relating not to the engineering problems of the automobile, but to the things which the engineer overlooked or could not solve, and which the ingenuity of men who lay no claim to the title of engineer, has enabled them to learn so that they may take a bucking auto and make it feed out of their hands and stand without hitching.

One of the first essentials of an automobile is that it shall go, and that no amount of perversity shall prevent the owner from "driving it back home under its own power." Anyone may be towed in, if there is a horse or another automobile handy; the wise owner will prepare himself to avoid this. Except for serious breaks of parts, or forgetfulness which permits oil or gas supply to run out, there is seldom reason why the average owner should not "get out and get under" to find out what the trouble is and, having found it, to remove the cause and start the engine. It usually should take only a few minutes. System in locating trouble and knowledge of what to do to remove the trouble are within the compass of all; if there also reside within the individual a few grains of common sense, his problem is simplified, his troubles are lightened.

Let it be said also that this book does not in any way pretend to supersede an automobile school for the owner who desires to make all his ordinary repairs, and do more puttering about the car than the average owner cares for. All owners would save the cost of instruction many times over and repay the lost time by taking a course of instruction in a reputable school. Many Y. M. C. A. branches all over the land have well equipped schools, and there are many others in the cities; there are also many where time spent would be wasted. There are several in one of our large cities where the expense is very small, but it is dear at any price. The "course" consists largely in putting the student to work in a garage as an apprentice, where his instruction is confined to verbal orders of how to repair a car which comes in. In time, of course, the student comes across a large variety of troubles, depending upon the character of the garage trade. Meanwhile the garage-auto-school proprietor permits the student to pay for the privilege of doing the repair work at the institution. No wonder the course is advertised as unlimited!

It should be understood that this book does not pretend to tell all the troubles attaching to automobiles and how to end them; but it covers the general run of difficulties experienced on the road and a close study of its pages and an application of its advice will make an owner who has the least mechanical genius independent of the garage man, with his delay and extravagant charges; at least it will enable him to get to the home garage in most cases, where repairs may be effected with a minimum of expense and annoyance.

Upon this basis and with this understanding, the automobile owner may safely pin his faith to what follows and plunge at once into its depths without fear.

H. C. B.
C. A. S.

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CHAPTER I

WHAT TO DO ON PURCHASING A CAR

THE man who buys a car will receive from the salesman a certain amount of instruction as to running it. He will be taught how to manipulate the pedals and levers, switches and other devices of the equipment and, if necessary, how to run the car. He will be given, also, certain books of instructions.

It is presumable that almost any man will remember enough of the salesman's patter to enable him to get home with the car, and that some bits of memory as to the instruction books will remain. But will the owner get out those books and go to school awhile with them? Not if he is the average owner. Probably he looks upon them as mere catalogues for ordering repair parts —well enough when needed. Do not make that mistake. There is no other book printed, no matter how complete, which supersedes or which can be substituted for the manufacturer's book concerning his own car. It was not printed just to consume paper and ink; the manufacturer had no idea you would cut out the pictures and paste them about the garage. He and his assistants spent a large amount of time and a larger amount of gray matter in preparing those books so that you, Mr. Owner, would know how your car is built, what it ought to do, and why it won't unless you do certain things. The books contain in a small compass practically everything about your particular car. The owner should master the contents first of all. Nothing can take its place.

If the owner has not read the instructions, lay down this volume right now, go to the garage, and get the books and read them over. If you haven't read them they are still in the car. The manufacturer made certain that the owner could not claim the books were not received, by tacking them fast under the seat or elsewhere so that they could not get away and so that a forgetful salesman would not overlook this important matter. Get them out and lay the basis of what is to follow.

Doubtless the owner will find that the manufacturer has, for instance, given certain instructions concerning lubrication, perhaps has specified certain kinds of lubricants. Now, no matter how much you may know about the subject of lubrication, rest assured that the manufacturer has had an engineer study out the lubrication of his car and what he writes concerning it is the last word and it should be followed implicitly. All that is contained in these pages upon the subject of lubrication is explanatory and corrective and in no way can take the place of the manufacturer's advice for the particular car.

The same thing is true as to tires, or brakes, or steering gear, or any other part of the mechanism. Read his book first and then turn to the appropriate chapter here and you will find no divergence, only interpretation, clarification, supplementary advice.

Probably it would be well to remind the owner that nine-tenths of the complaints which reach the manufacturer or his service stations, show that the owners making the "holler" confess that they had not read the books given them with the car. It has become such a serious thing that at least one manufacturer has started schools for purchasers of the make, where, at a nominal compensation, they may be made to read the instructions and be given a visualization of what they mean. All owners cannot visit the centers where such schools are maintained, and all manufacturers do not maintain them now, though it may be necessary in the near future. The fact that it is necessary, however, should leave the impress upon the reader's mind of the importance of the subject.

The owner, whether he possess a "flivver," or an edition *de luxe*, has about as much money tied up in his car as he feels he can devote to that form of pleasure or to business. It is an investment which will, or will not, bring commensurate returns in money, or moments, well spent; it can be made an indispensable aid to both business and pleasure, or it may become an unsufferable nuisance in either. The value of a car depends not upon the amount of the purchase price, but upon what can be gotten out of it: its service, its dependability and general reliability; that and the low cost of upkeep and operation.

Would it not seem reasonable, therefore, for the owner to give as much thought and study to the machine which propels him and his merchandise as to the machine in the factory which produces the merchandise; ought he not to understand how and why and wherefore it propels him—or why not?

Few men there be who would consign their bodies to the mercy of wind and waves if they did not believe that a competent captain and engineer were aboard the craft, or to a railway train were there not an engineer and conductor at hand to look to his safety. Why should he place himself and loved ones in a motor car and start off on a trip with an uncertain hand at the steering wheel, with no one aboard competent to rule the engine, or to know if all other parts of the mechanism are properly adjusted, when a maladjustment may mean danger and even death?

One would not waste sympathy upon the owner himself in case of an accident through ignorance, but the fate of others in his keeping prompts the sounding of a warning.

Years ago traveling sign painters decorated trees and rail fences and barns along the railways with injunctions of a religious nature, such as "Prepare to Meet Thy God." The last time the writer was back "at the farm" this identical message confronted him from a big rock alongside the railway crossing, as it did thirty or more years ago. Only this time it seemed appropriate, for there was more recklessness shown than one cares to witness regularly—it is too nerve-racking.

When one considers that a defective brake, a worn-through steering knuckle, or any one of a number of broken parts—broken because neglected—may be the particular weapon selected by the fool-killer, the owner who cares for his bones, or for the lives of his passengers, would better spend a few hours occasionally in looking after his car and in finding out all that is possible about it.

Even though the owner can afford a chauffeur who "knows all about an auto," it is noticeable that chauffeurs have a way of forgetting, that they loaf on the job shamefully, that they conspire with the supply dealer to run the cost of upkeep to skyline altitudes, and are little more immune from road troubles than the common or garden variety of owner. The owner who knows can detect all these lapses from strict rectitude, to the comfort of his person and the safety of his bank balance.

So, now, having turned to the manufacturer's books of instructions and pondered over the warnings here given, the reader may safely pass on to the chapters dealing with the beast he is called upon to tame.

CHAPTER II

SOME THINGS TO AVOID

WHEN a certain character of history, long touted as "the wisest guy ever," uttered his famous "Wisdom crieth aloud in the street," and along with it, "Fools hate knowledge," he must have had a vision of the present day, when there is so much and so little known about the chief mode of transportation, the automobile; so much by those who really have studied its mechanical principles, and so little by those who are running them about the highways. Yet in this day of automobile schools and service stations there is no need of a single individual being ignorant, nor of his coming under the condemnation of the same wise one: "The careless ease of fools shall destroy them."

Give me an individual of average intelligence in overalls and jumper and a mind devoid of the "I know it" error and 99.99 per cent. of such can be taught to "make the auto auto as it really ought to auto." The chief obstacle is the half knowledge—half error—which some possess.

Josh Billings once said: "I'd rather not know so much than know a lot that is not so." The reader will get the idea.

One of the hardest things for the average man to learn is not to do useless things. Over and over folks will do things contrary to all rules and instructions and make extra work for themselves. In a school it is a good thing, perhaps, for it enables the instructor to point out the futility of going at the thing wrong end first. There was one class at the West Side Y. M. C. A. school particularly stupid in this respect. They were set to locating engine troubles, forgot all about the rules and took turns cranking the engine, expecting in that way to find out why the engine would not run. The instructor, looking into the classroom, found how things were going. All but one student were intent upon turning over the engine; that one man stood in one corner grinning, apparently having a good time with himself. The instructor in feigned amazement called out to him:

"Here, why are you not cranking the engine, too?"

With a grin perfectly idiotic the fellow drawled out:

"What's the use of cranking if she ain't goin' to run?"

The reader can figure out for himself the relative degrees of idiocy or stupidity in that class. The instructor quickly set them to work by rule and they all knew in a few minutes that troubles are not located by cranking alone. The reader who will give careful attention to the instructions herein contained, and who will follow closely the rules, will not be cranking the engine when he should be cleaning a spark plug, or adjusting the carburetor, or mending a broken wire. He will learn that there is a sequence in every little job about the auto which tends to lessen the labor and to produce the best result, just as there is in keeping a set of books, or in running a farm.

The carpenter who does his work without plans usually is dubbed a "wood butcher." The inference is that the man who would care for his automobile should learn to do it in a systematic way, according to rule, doing everything always the same way and in the same order. Thus the labor becomes a habit and is performed quickly and easily. At the same time habit must not be allowed to become a rut; the owner must preserve originality and initiative, and native ingenuity is invaluable.

Particularly it is wise to avoid the idea that at the first sign of something wrong one knows just what the trouble is. Probably no one thing has caused more unnecessary work and unnecessary expletive than jumping at a conclusion. Have a rule and go by it. Under the chapter relating to troubles there will be found a rule for locating them. It does not matter so much where one starts if it is followed through when started. Experience will lead one in time to select the starting point, either under the heading ignition, or gasoline, or other heading, the symptoms indicating generally to the experienced ear what is the matter; but there is so much chance of error in this guess that the rule must be remembered and closely followed.

It takes three things to start a gas engine running: gasoline in the proper mixture, compression, and ignition. To keep it running we must add a lubricating and a cooling system. There must also be free exhaust for burned gases. While there are many phases of each, it is necessary for the owner to get these things fixed in his mind first. Everything else is extraneous.

There is something else to avoid. Avoid giving offense to the policeman on the street, and avoid running away if you have had an accident or are hailed by the traffic man. It does not pay, and will make added trouble, unless you are as fortunate in explanations as was a fellow who was caught by the officer in front of the Automobile School. He had hit someone and instead of stopping as the law provided, he gave a hasty look, saw no policeman, and shot ahead, turning the next corner. He dodged in and out of several streets, not seeing the motorcycle policeman chasing him. When caught and stopped he was asked why he was running away.

"Me running away?" he asked. "I was not running away, I was just trying to find a cop to report the accident."

It worked that time, but it is not safe to trust the expedient under other circumstances.

CHAPTER III

WHAT AN AUTOMOBILE IS

It matters not whether one call it an automobile, a tin lizzie, a gas wagon, or what not, it consists of a steel frame upon which are mounted wheels, an engine, appliances for connecting the engine to the driving wheels, a fuel supply tank, a system for producing ignition at the right moment, and appliances for regulating the speed of the engine and the direction of the car. A seat for the driver and sundry pedals and levers are needed to accomplish speed and steering control, and sundry other parts have their place, but the above covers in a general way the necessities of an automobile.

An automobile, as the name suggests, is a car which contains its own propelling force and to which it is not necessary to hitch a horse, or steam engine, or something else to make it go. This in spite of the fact that occasionally it *is* necessary to hitch something else to an auto to make it go.

The assembly, generally speaking, consists of the chassis, corresponding to the running gear of a wagon; the engine, mounted on the chassis; and the body.

The chassis usually is made of angle iron riveted together in form convenient for supporting the other parts. This rests upon the springs which take up the road shocks in part, and the springs rest upon the axles.

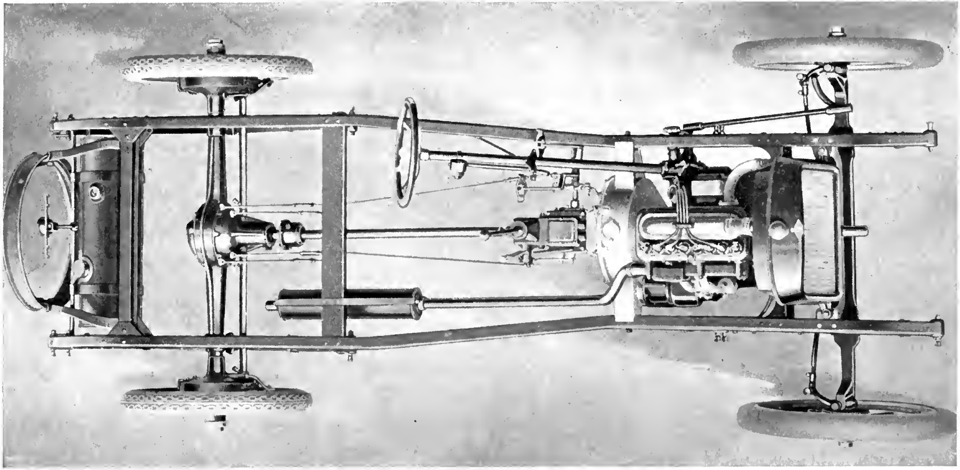
The rear axles—there is a separate axle for each rear wheel—are fixed, that is, they keep the wheels from oscillating, and they are joined in the center by the differential, a device driving the axle shafts by which one wheel is permitted to revolve at a differing speed as compared with the other, in turning a corner. Since, in turning, the outer wheel must travel a much longer distance than the inside wheel, if no device were installed to take up this difference, the outer wheel would scrape over the ground on every curve, or the inner wheel would spin without forward motion. In either event it would be disastrous to tires.

To keep the differential housing from twisting, a torque rod or tube connects it to the frame; to keep the rear axles at right angles to the frame and to transmit the driving thrust to the load, radius rods connect the axles to the frame forward.

The forward axle, unlike in an ordinary wagon, is fastened to the chassis frame, through springs, and does not turn. On either end is a yoke from which is suspended a steering knuckle, the wheel turning on a tapered spindle forged with the knuckle. The two knuckles are fastened together by a tie rod, which has some form of a turn buckle by which the wheels may be made to run parallel, or practically so. As a matter of fact the wheels are not parallel. They foregather slightly, so that the lines, projected forward far enough, would meet and make a pointed effect, like the bow of a boat. Its effect is to bring a slight but constant pressure upon both wheels and makes them less likely to swerve through contact with road unevenness. Also the wheels undergather, so that the load is brought over the center of knuckle support, minimizing the strain.

This deviation of the wheels from true produces a very slight wear on the tires, but it is more than compensated for by the other advantages noted. The deviation is worked out scientifically and the owner need not trouble himself about it. His only concern is that the tie rod be not bent so that the foregather is increased, when there would be excess wear of tires.

The brake drums are attached to the rear



Courtesy of Allen Motor Co

CHASSIS OF A MODERN AUTOMOBILE WITH FOUR-CYLINDER ENGINE

wheels and have inside and outside bands with mechanism to tighten them against the drum providing the necessary friction. The levers which connect the bands to the brake pedal or emergency lever are termed the brake linkage.

The motor, or engine, rests upon the chassis frame forward, being fastened thereto by bolts. Forward of it is a radiator, if it is a water-cooled motor, to which it is connected by pipes; the cooling system may be either pump or thermo-syphon type. Some few motors are air-cooled. The principle of cooling is that the motor should be kept just cool enough to prevent the lubricating oil from burning off the cylinder walls.

Attached to the motor are the carburetor, in which air and gasoline are mixed properly for rapid combustion, wires to supply ignition to the mixture at the proper time, a device for giving lubrication, and exhaust pipes leading to the muffler, the latter designed to stifle the noise of rapid explosions, which otherwise would be deafening.

The ignition system may be either battery and coil, or high-tension magneto which has its own coil and distributor, or a combination of both these systems. Where there is a self-starter there is a storage battery, which supplies current to the starting motor, and from which the ignition current is drawn, and a generator to keep the battery charged, and the generator may be provided with a circuit breaker and distributor, or a separate magneto or coil may be used.

The lubricating device may either be a gravity or force-feed oiler system with pipes leading to the various bearings, or the chief lubrication may be by the splash system, where a reservoir of oil is kept under the crank case from which it is pumped to oil pans under the cranks, being splashed by projections which dip into the oil and throw it all over the inside mechanism.

Also attached to the carburetor is the pipe from the fuel supply tank. This supply may come by gravity or under pressure, and a late device which is furnished with many cars is a vacuum gravity system, the gasoline being drawn from the main tank, by a vacuum created in the intake manifold, into a small container attached under the hood, whence it flows by gravity to the carburetor, maintaining a uniform supply.

The motor consists of one or more cylinders, inside of each being a piston which fits tight, the escape of gas being further prevented by piston rings which seal the cylinder with the aid of the lubricating oil. The pistons are attached to a connecting rod by a wrist pin, the connecting rod being attached at the other end to the crank which rests in bearings. The action of the engine is that by drawing down the piston a vacuum is created in the upper part of the cylinder called the combustion chamber. At the right moment an inlet valve is opened and a charge of gas and air, called mixture, is sucked in. The valve closes and the piston rising compresses the charge. When the piston reaches its highest point a spark is introduced through spark plug or igniter. This fires the mixture, bringing a rapid expansion, and this drives the piston downward, producing force. This revolves the crank shaft, which turns the force into rotary motion. This operation repeated rapidly furnishes the motion which drives the car. The fly wheel carries the crank over the strokes which do not produce power.

There are four strokes to each motor cycle. The first, which takes in the mixture, is called the suction stroke; the next is the compression stroke, the third is the power stroke, and the last is the exhaust stroke when the burned gases are expelled from the combustion chamber. These four strokes take two complete revolutions of the crank shaft, so that the four *cycle* is really two *circles*.

2

Power having been created and turned into motion, the next step is to connect it to the propelling or drive wheels. The first device for controlling the power is the clutch, which provides means of applying or cutting off the power or motion quickly without stopping the engine. This is done by friction in some form. The most common are the cone clutch, where male and female cones are engaged by pressure, the friction transmitting the power to the driving shaft; and the multiple disc clutch, where numerous thin discs of metal or metal and textile material are compressed together by a lever and transmit the power.

To provide for varying speeds and for reversing, also extra power to the rear wheels for hill climbing, sandy roads, etc., gears are necessary. In a general way this is a set of cog wheels of varying sizes, so arranged on parallel shafts that by engaging different size gears on the shafts a certain speed will be transmitted, other gear sets producing another speed or a reverse motion. The diagram in Chapter XXI. shows the usual form of construction. Three speeds and reverse usually are provided, though some cars have four speeds. These gear sets are engaged successively until the desired speed is reached.

From the gear case the power is transmitted by the drive shaft, which has one or two universal joints to take up any misalignment and to enable installing the engine level and yet transmit the power to the driving axles, through the differential, at another level or angle, or at varying angles due to spring action.

Upon each of the wheels is a tire consisting of a rubber and fabric casing, enclosing a soft rubber tube with a valve by which it may be inflated. The purpose of the tires is to absorb road shocks and make riding easy, as well as to keep the car from jolting to pieces. The tires are of varying composition and form and are attached to the rims in differing ways. Many auto trucks use solid rubber tires.

Without going into detail, the foregoing gives the makeup of the car and the simple principles of its operation. To control the car requires various other parts. The first is the steering wheel and its mechanism. The wheel is mounted on a shaft running within a tube, and to the lower end of this shaft is a worm controlling a gear, and by levers and ball joints operating the steering knuckle on one of the front wheels, the other being operated simultaneously by the tie rod connection. On the steering wheel or steering column are mounted the spark-timing lever and the throttle lever. The spark lever regulates the time of the spark within the combustion chamber and the throttle the amount of mixture admitted to the combustion chamber.

At the feet of the driver are the pedal for engaging the clutch, that for applying the brake, and the accelerator pedal, which operates the throttle as well as the lever before mentioned. The throttle lever on the steering column is for the regular running adjustment, while the accelerator pedal is for temporary increase of the mixture in starting or in speeding up. There may also be a pedal for the self-starter, though the switch often is upon the dash. On the Ford and some other cars the gear shift is controlled by pedals, but usually the shift is made by a lever placed convenient to the right hand of the driver. With it is installed also the emergency brake lever, which is used for locking the car when standing and for alternating with the foot brake on long hills.

On the dashboard may be mounted the ignition and lighting switch, the speedometer, sight oil feed, and sundry other dials and switches, depending upon the fastidiousness of the owner. Where there is a self-starter there is a charge and discharge dial, the ammeter, which tells whether the generator is working, and how.

CHAPTER IV

WHAT MAKES THE ENGINE GO

As has been stated on a previous page, it takes three things to start an engine and three more to keep it going. The first three essentials are a proper mixture of gasoline and air, ignition at the right moment, and compression.

Gasoline will continue to burn after ignition, but, contrary to the common idea, it will not explode unless confined, and not even then unless it has vaporized and the vapor is mixed with air. It takes about two hundred cubic feet of air to a pint of gasoline vaporized to produce good combustion, though the air supply is usually much more than this to insure carrying off the unburned nitrogen from the air. For starting and speeding up, more gasoline is admitted to the vaporizing chamber as the rich mixture ignites more quickly, but for running, a leaner mixture produces better results.

But whatever the mixture which is burned, there would be little or no power produced if the mixture were not confined under pressure. It is, of course, a fact that a tank filled with gasoline vapor and air will explode with great force if ignited, though there be only the ordinary atmospheric pressure upon the tank. But it must be remembered that if the pressure were sixty or seventy pounds to the square inch the explosion would destroy everything in the vicinity. Taking advantage of this fact the designers of the gasoline engine provided for compressing the gas before ignition, to produce the greatest amount of power for driving the car. Valves are provided which admit the charge of mixture to the combustion chamber, closing tight after the charge is received. Then the piston rises, compressing the contents of the combustion chamber until a pressure of between forty and seventy-five pounds per square inch is reached. It is upon the principle of the muzzle-loading rifle or shotgun, or in blasting, where the charge is tamped down, or confined by wads, and the exploding powder is held until the pressure sends the bullet on its errand, or rends the rock.

Just as the piston reaches the highest point, and the compression is at the maximum, a spark is introduced into the combustion chamber. Under the pressure the gases burn much more rapidly and the explosive force is greater. The gas does not burn instantaneously, however. It takes a distinct interval of time for all the gas mixture to ignite; for this reason, when the engine is running under its own power, the spark comes just before the time of greatest pressure, and before the piston reaches top center, so that by the time the piston starts the downward stroke the highest efficiency of power will have been reached. For this reason the spark-timing control lever is advanced after the engine is started to give the best results. But the engine is always cranked with the spark fully retarded.

The carburetor, meanwhile, has been called upon to send into the combustion chamber through the intake manifold and intake valves a charge of gas mixture; the quantity is regulated by the throttle. For starting, a lever is manipulated which depresses the float in the fuel chamber of the carburetor, permitting an extra supply to be drawn into the mixing chamber, thus making the mixture richer and more readily fired. When the engine has started running, the throttle is closed to a point where the motor does not race. The correct running position is given by the manufacturer and experience will soon determine where the best results are obtained.

The ignition system must deliver to the combustion chamber at the right instant a spark of sufficient intensity to fire the charge. Whether the electric current is obtained from battery or magneto, it must be hot enough to do its work and there must be a timing device which will send the spark into each cylinder when it is needed. These come in several forms and are described in detail in the manufacturer's instruction books, in connection with the ignition and wiring diagrams.

The compression is maintained when the piston rings and grooves are free from gummed oil or carbon and move freely; when the cylinder walls are not worn oval by a slapping piston, or creased by carbon, and when a film of lubricating oil is constant on the side walls and when valves are properly seated. Loss of compression means loss of power and the cylinders should be tested every little while to make sure that no cylinder is failing to do its duty. More will be said concerning this later, as well as of minor things which may affect the compression.

As has been mentioned, to keep the engine running for any length of time there must be a cooling system, a system of lubrication, and a free exhaust. Once the owner comprehends the simplicity of gas-engine operation, he can begin to trace each part of the operation, learning all there is to know concerning the several steps in his own motor, and absorbing the specific knowledge which will enable him to care for his car efficiently and economically.

CHAPTER V

EQUIPMENT AND ACCESSORIES

WITH every car are furnished all the things required for operation, including lamps, tire pump, jack, tire-repair kit, a variety of wrenches to fit all nuts and bolts, oil can, set of spark plugs and generally an extra one; hammer, screw driver, cold chisel, magneto-adjusting wrench, and some other things, varying with the car.

There are any number of additions which may be made in the way of tools, or of devices which some motorists deem desirable. Some of these things are a speedometer, a clock, trouble lamp attachable to a socket on the dash, a mirror to enable the driver to see what is going on back of him (compulsory in New Jersey and some other States), cigar lighters, foot warmers, and elaborate lights for the limousine. The owner is cautioned, however, against loading up his battery with a lot of electrical devices which use up current very fast. Not so as to tools; one may err in having too few rather than too many.

While it is true that a woman with a hairpin and a piece of string can fix almost anything under the sun, the autoist would better not trust to his wife's ingenuity, but be a little better prepared for the emergencies of the road. It does not do any good to know what the matter is when the car balks unless one has the tools and material to do the necessary repair work or adjustment.

Every new car is equipped with certain tools, but some owners have no interest in these tools and lose most of them in a short time, so that when needed they are missing, while other owners add sufficient tools to equip a good-sized machine shop.

A wise selection of tools for the car will provide everything at all likely to be needed on tour, and yet capable of being packed in such a compact space that it does not become an annoyance through the room occupied, nor weigh down the car. The special tools furnished should be preserved with great care, because nothing else fills the bill quite so well. To these might be added some few tools and parts not needed often, but when they are, their absence is a source of delay and is temper-provoking.

Recently the author was asked to go about fifty miles into the country to bring in a machine which had refused to run and had been stored in a barn over night. He found that the interrupter points had become glazed so that no spark was being procured. A special file is manufactured for the particular purpose of cleaning off these points. As one of these was not in the car, it was necessary to disassemble the spark timer completely, take out the points, and then find a piece of flat hard stone upon which the points could be cleaned. This did the work all right, but much time could have been saved if the interrupter point file had been carried in the car.

Likewise no wrench was available for adjusting the points and it was necessary to go to a nearby blacksmith shop and saw out a temporary wrench for the purpose. Word has come from France to the National War Work Council of the Y. M. C. A. that one of their supply cars serving the huts in the trenches was laid up nine days for the lack of a small magneto wrench.

Many an owner has had the experience of being caught out on the road by a storm and having to put on non-skid chains. How often have they found that, though these chains were in good condition when leaving the garage and when they were put on, after running awhile over rough roads at a fair speed, some of the links wore through and began to thrash against the mud guards. This is not only annoying, but often does real damage to the guards. Most owners have stopped more than once to wire the loose ends to the side chains to stop the banging, and it certainly would be more satisfactory to carry a supply of links and a chain tool so that the broken ends could be removed and new links inserted.

Of course, the loose ends can be pried off with a screw driver and new links pounded fast with a hammer, but you will have to remove the chain to do it and it takes time, and much exasperation can be saved by using the proper tool.

A folding pail is very useful, especially when one has to go up very long hills and finds that the water in the radiator has boiled away. The cooling systems for automobile engines to-day are very efficient and it is only in exceptional cases that the water will boil out of the radiator, and that is just the reason why an occurrence of that sort is disastrous, because one is not expecting it and is not prepared for it.

In sandy country and on dirt roads one often will have occasion to jack up a wheel to change a tire, and will find that the jack sinks into the loose sand or dust instead of lifting the car. A block of wood an inch thick and about six inches wide and a foot long will be found a big help under such circumstances. Many drivers also have had to use a fence rail to jack up a car because some one borrowed the jack from the car and neglected to return it. Even though tire trouble is not expected, it is well to make sure there is a jack in the car and also a handle for the jack. The jack is more often found than the handle.

Working about an automobile means a lot of grease and grime on the hands, and possibly oil or grease upon parts of the car, so that it is well to carry a small bag of waste or rags. If the grease or dirt prove obstinate, a little gasoline, drawn from the drain cock at the bottom of the carburetor, will cut it and enable you to clean the hands fairly well.

It is a good idea to have a three-in-one or similar tire-valve tool with which it is possible to remove the valve plunger, cut threads in the valve stem so that the plunger may be properly seated, and cut threads on the outside of the stem so that the cap will screw down tight. In some cases where the valve stem is battered in changing a tire, air cannot be gotten into the tire if these threads are damaged.

Many persons object to carrying a tow rope for fear it will be understood that they have doubts of their ability to get home under their own power; but in addition to affording a connection to some other source of power, a tow rope may be used to help a brother in distress and is superior to chains in very sandy or muddy places, when wrapped about the tire.

An extra set of electric-light bulbs may save considerable trouble and annoyance, because the traffic policemen to-day will accept no excuse when at least one light is not burning.

If you do not take your wife's first-aid kit—the shoestring and hairpin—you had better be provided with a spool of soft iron wire, the ordinary stovepipe wire. It is wonderful how many little temporary repair jobs may be done with its aid. Some drivers like to have a small hank of strong twine also.

There are many other things which might be added to the list of useful things to have along for emergency, all of which may be stowed in the tool box or under a seat. They may not be needed once a year—perhaps never—but like the insurance policy, when you do need a tool you need it pretty badly.

AUTOMOBILE FIRST-AID KIT.

1. Wrench for adjusting ignition interrupter points.
2. File for cleaning above points.
3. One set of ignition brushes. (In box labeled.)
4. Several extra spark plugs, cleaned and adjusted ready to use.
5. Tow rope.
6. Half-dozen valve plungers for inner tubes.
7. Three-in-one tire-valve tool.
8. Tire pressure gauge.
9. Jack and handle. (Be sure about the handle.)
10. Squirt can full of oil.
11. Voltmeter, or hydrometer, for testing battery.
12. Box of assorted nuts.
13. Box of assorted cotter pins.
14. Box of assorted cap screws.
15. Box of assorted washers.
16. Spool of copper wire and one of soft iron wire.
17. Full set of electric-light bulbs.
18. Bag of clean waste or rags.
19. Two blocks of wood, 6″ x 12″ x 1″.
20. Full set of fuses—if fuses are used.
21. Folding pail.
22. Chain tool and several cross links.

The nuts, cap screws, washers, and cotter pins of regular assortment and packed in boxes are carried by supply stores. These and several of the other articles may be packed in a cigar box for stowing away.

CHAPTER VI

IF WELL "SLICKED" THE ENGINE RUNS

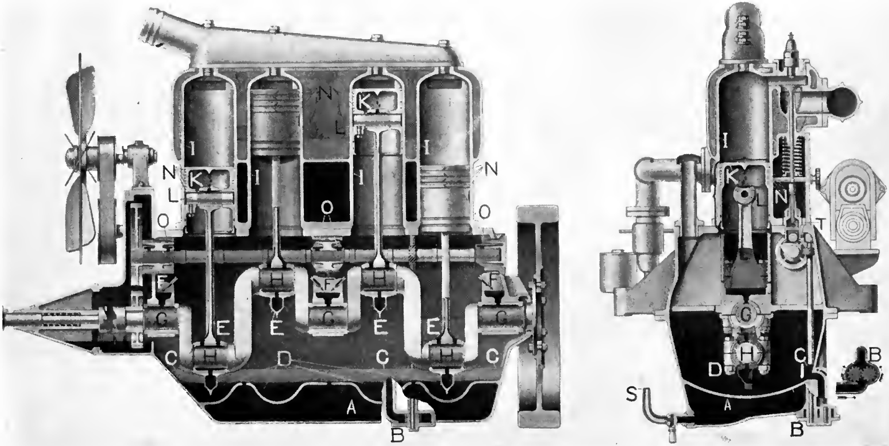
If we scuff our feet on the bare pavement we wear out our shoes, develop a lot of heat, and notice considerable resistance; but if we step on a banana peel, a piece of ice, or a patch of oil or grease, our passage is facilitated, and our feet are likely to slide out from under us and we sit down with little effort. Now this is just like the auto engine. If the parts were all made perfect and fitted together properly and the engine started without lubrication, there would be so much friction that the parts would very quickly wear out.

As a matter of fact an engine could be wrecked in less than half an hour's running, unless there were something introduced to prevent friction.

The lubrication of the modern auto engine is so simple that most owners do not realize its importance. It is the things which normally take care of themselves that are most likely to be neglected; the things about which we know the least, when they do go wrong, cause the greatest damage, not the things with which we have become familiar through frequent tinkering.

The instruction books issued by the manufacturers say to inspect the oil reservoir of the engine each time before leaving the garage to see if the required amount of oil is there; and this inspection should not be neglected; with most owners it is "by guess and begorry."

The most usual scheme of engine lubrication used to-day is to carry a certain amount of oil in a compartment in the bottom of the crank case, called the sump. There is a pump which operates whenever the engine is running and which pumps the oil to some sort of an indicator on the dash, so that the driver can see if it is circulating. From this point it flows by gravity to the splash pans located under the connecting rods, and above the sump. Here the oil is held at such a level that when the crank shaft revolves the ends of the connecting rods dip into the oil and splash it over practically all the working parts of the engine. This splashing and agitation of the oil creates a fog of oil in the crank case, and the rapid motion of the piston and other parts circulates the vaporized oil over the moving members, so that a film of oil is



Courtesy of Tide Water Oil Co.

SECTIONAL VIEWS OF A FOUR-CYLINDER ENGINE WITH SPECIAL REFERENCE TO PARTS CONNECTED WITH LUBRICATION

A	Sump	F	Oil Cups	L	Wrist Pins
B	Oil Pump	G	Main Bearings	M	Basin in which Crank Shaft Gear Runs
C	Crank-case	H	Crank Pin Bearings	N	Piston Rings
D	Troughs for Oil	I	Cylinders	O	Oil Pockets
E	Connecting Rods	K	Pistons	S	Drain Cock or Oil Gauge
		T	Push Rods		

deposited even on those parts where the splash itself does not reach.

The pump circulates more oil than is used and the splash pans are arranged with overflow openings so that the excess simply drops back into the sump and again is passed through the system by the pump.

It is this oil which enables the engine to move without friction. It is the effect of the banana peel under your heel in that it makes the parts slip over each other easily. In addition to this the oil between the piston and the cylinder wall makes a seal which prevents gas from leaking by on compression and explosion strokes. If too much oil is fed a great deal will be drawn past the piston on the suction stroke and get in the cylinder where it will burn, forming carbon and giving out smoke from the exhaust.

In this type of system the principal causes of trouble are too much oil in the sump, so that the level reaches above the splash pans, and projections upon the connecting rods that are so large that too much oil is splashed when the level is normal. In the latter case the trouble often may be remedied by narrowing the projections of the connecting rod which dip into the oil. It is not wise to shorten these projections, because it is very difficult to get an even graduation that will insure sufficient oil without giving too much.

If the oil should run out while the car is in use, the engine will get stiff, lose its power, and the friction of the unlubricated parts will generate sufficient heat to melt out the lining of the bearings, and if the engine runs for any length of time in this condition it may be wrecked beyond repair.

This means that although the oiling system needs very little or no attention, it should be inspected each time before leaving the garage and on the road occasionally if long trips are taken, to make sure that oil is present in sufficient quantity and is circulating.

Oil in a sense does wear out and in this sort of a system it should be replaced with new oil occasionally. Some of it will work up past the piston and be burned up and some will work out around the different parts of the engine and be lost, but most of it will remain in the sump longer than it is advisable to use it. All of the gasoline that is taken into the cylinder is usually not consumed. Some of it is forced past the piston on the compression stroke into the crank case, where it condenses and mixes with the oil. This thins the oil sometimes to a point where it has little or no lubricating value. Also the oil on the inside of the piston head burns and drops down into the crank case, and there is some wear of the moving parts which causes a deposit of metal in the oil. These things, together with the small amount of road dust sucked in through the breather pipe, make the oil in a short time unfit for use.

In this circulating splash system, where the oil is used over and over again, the oil should be drained out entirely about every 1000 miles, more or less, depending upon the grade of the oil and fit of the piston. The following things all enter into the lubricating value of the oil after 1000 miles' performance:

Grade of the oil
Fit of the pistons
Temperature at which the engine is run
Grade of the gasoline
Adjustment of the carburetor.

There are some other things, but the above are the chief factors. It would be well to acquire the habit of examining the oil every few days to determine just how it stands up in the particular engine.

After the oil is drained out, a half gallon or so of kerosene should be poured into the sump and the engine run for about one minute or less, the idea being to get a complete circulation of kerosene through the lubricating system. The kerosene should then be drained off and the splash pans under the connecting rods be wiped out if possible. The screen of the oil pump also should be removed and washed carefully in kerosene and replaced. Then the sump should be filled to the proper level with fresh oil.

Aside from getting under the car to remove the drain plug, this is not a dirty job. Still one would better put on old clothes and overalls to prevent the possibility of getting grease on a perfectly good suit.

While oil is expensive, it is poor economy to use it beyond its useful stage, because damage may be done to the machinery which will cost much more than a year's supply of good oil.

CHAPTER VII

WHERE LUBRICATION IS NEGLECTED

In some of the minor and oftentimes hidden parts of an automobile are found frequent sources of trouble. There are places to be lubricated of which many an auto owner has no knowledge. They wear slowly but constantly, and unless given proper attention will erelong give trouble.

There are a number of these lesser bearings which tell the expert whether the car has had proper care. In fact, in looking over a used car the man who knows naturally turns to these first to find out how well the car has been taken care of. Experience shows that even where other parts show normal, or practically no wear, these lesser bearings show absolute neglect, and these are "the little foxes that spoil the vineyards" in the auto world.

Practically every owner will fill up the oiler to insure engine lubrication, because that is a regular task; most men will remember to keep oil in the transmission case and the differential housing;

probably a lesser number will put grease in the wheel bearings when needed. As the latter is not required very often, it is frequently forgotten.

What are the neglected parts? Well, when the expert looks into the condition of a car, one of the first places he inspects for wear is at the steering knuckles. One must realize that they are under a pretty heavy load, and that, while the motion is not great, there is a continual motion there, even when the car is driving straight ahead. Very few have learned that it needs a constant supply of good, heavy grease to prevent wear at this point. It is worth while to screw down on the grease cups on the steering knuckles every time oil is put in the engine. When the grease cup is screwed down so that it cannot be turned further, it should be filled immediately. There should be enough grease there to keep forcing it out, so that grit cannot get into the bearing.

Underneath the floor boards there are a number of parts which need attention, but being out of sight they are often out of mind. They are a little inconvenient to get at, also. Under there we have the universal joint. This is another joint in which the motion is not great, but the load is heavy and continuous. That is the next place that usually shows hard wear. There are one or two modern designs which have housings covering this joint which may be filled with heavy oil and it then takes care of itself for a month. It should be inspected and the oil replaced once a month.

Certain universal joints, not generally used, however, are supplied with grease cups, which need attention every time the car is used, just as much as the oiler in the engine.

Also underneath the floor boards are the levers and arms used for controlling the clutch and brake, the self-starter and the accelerator. All have bearings, used occasionally, but enough so that they should be kept lubricated or they will wear. This is especially true of the clutch and brake linkage, particularly in city running, where the clutch and brake are in constant use. Usually this linkage has no means of lubrication other than oil holes, into which a drop or two of oil only may be placed. Naturally it will not last long and oil should be dropped in the holes at least once a week.

This is also true of the brake linkage on the rear axle. Often at that point no provision whatever is made for oiling. It is simply a matter of flowing oil around the joint and letting it work in. If the brake linkage wears and weakens and it becomes necessary to apply the brake with extra force in an emergency, it will give way.

The spring shackle bolts usually are equipped with grease cups and they do not suffer quite as much as other points, but often the passages become clogged and one may screw down on the cup and only force the grease out of the thread of the cup, instead of into the bearing, for the grease-cup cap fits loosely upon the thread.

Many cars come from the factory with the grease holes clogged with enamel, or hardened grease, so that no great amount of grease could be forced through in turning down the cap. Cars are allowed to run so long sometimes in this condition that the shackles have worn through, allowing the body to drop down on the axle.

Very often complaint is made that a new car will develop a squeak very soon after it is tried out—an elusive sort of a squeak that seems to be first one place and then another. The owner who has this experience will probably find upon examination that the spring shackles have not been lubricated, either because the hole was clogged, or for some other reason. It is recommended that in such cases the car be jacked up and all the shackle pins be driven out and all the grease passages inspected and cleaned thoroughly; also that heavy grease be applied directly to the bolt when it is put back in place.

This will take a little time, but it pays, for it is a matter of experience that if the pins are not driven out and the holes opened up for inspection it will take a solid month to force the grease through by screwing down the grease cup, and until this passage is open there can be no lubrication of the joint.

Wheel bearings ought to run for six months if properly packed, but there is no way of telling when the bearing needs attention except by inspection and it is well to look them over regularly. When inspecting the rear-wheel bearings, if the construction is of the type where the wheel hub is keyed on to the shaft, it is well to inspect the key to determine whether it is tight. Out of four cars recently inspected three were found with a loose key.

There are two dangers when the key is loose. One is that the key way becomes rocked out of shape and the key cannot be fitted tight again. The other is that shaft and hub may become so worn that the taper is destroyed and a tight fit is made impossible, and of course the only remedy is to replace both. This condition will often account for a knocking or rattling, which will be felt throughout the car and the cause often be supposed to be located far from the real place. For instance, in one case the driver thought the knocking was in the gear case, until shown the loose hub.

The spring leaves need lubrication once a season. Tools are sold for separating the leaves enough to apply a lubricant made especially for that purpose.

Another part which shows hard wear quickly is the valve push-rod guide, especially in overhead valve construction the ones on the forward end of the motor. Dust blowing over the radiator collects on these forward guides and wears them rapidly. This condition is indicated usually when the crank case becomes covered with oil blown up from the loose joint. Modern designs have taken care of this to a large extent by enclosing the push rods in a casing, and many owners have put in housings themselves when they discovered the difficulty.

Overhead valves, worked by a rocker arm, must be lubricated every time the car is taken out. The lubrication is not included in the ordinary lubrication scheme of the engine, but must be done separately.

Careful attention to these minor points will result in greatly lengthened life for the car, and in a much higher value when it is traded in for another car. The man who buys a used car would better inspect closely along these lines if he desires to buy something better than a bunch of junk. The owner should not trust to his chauffeur the care of these parts, unless he has found out that the man knows of the importance of lubrication, nor should it be taken for granted that the garage man is attending to them. Make sure yourself is the best rule. It is well to remember that "many a mickle makes a muckle" in wearing of auto parts, and look after the little things.

CHAPTER VIII

SOMETIMES THE CAR SMOKES

THE officer will get you if you don't watch out, if you leave a trail of smoke behind you; then it will be:

"Good morning, Jedge, your Honor."

"Guilty? Two dollars, please."

"Cheap," you say. Yes, if it were only the two dollars; but there is the time lost in appearing in court and then, really, you know, to make that smoke you were burning money.

Such smoke comes from two sources: Burning too much gasoline and using too much lubricating oil; usually the latter. Excessive use of gasoline comes from faulty carburetor adjustment, or poor design of carburetor or intake manifold, or keeping the engine cylinder at too low a temperature, because of the water being too cold in the cooling system.

In the latter case the carburetor may vaporize the gasoline properly, but it condenses in the cylinder and does not burn well and the part which is not consumed passes off as black smoke, which issues from the exhaust pipe.

We must have a certain amount of oxygen to consume the gasoline entirely. The size of the cylinder limits the amount of air (from which the oxygen is taken) which may be taken in and if the carburetor is adjusted to feed too much gasoline, there may not be enough oxygen present to consume it all. Practically speaking, what is not consumed forms carbon or smoke.

The obvious remedy is to adjust the carburetor so that no more gasoline will be fed to the engine than is required for running. In cold weather it is necessary, usually, to supply heat to the ingoing air at the mixing chamber of the carburetor, so that the vaporization will be complete.

A light blue smoke coming from the exhaust pipe indicates too much lubricating oil. This may be due to feeding too much oil or to running the engine a great deal with the throttle nearly closed. In order to draw a charge of gas into the cylinder the piston travels partly out of the cylinder and forms a vacuum. With the throttle wide open a high vacuum is not obtained because a large amount of gasoline and air is allowed to come in and fill the cylinder. When the engine is throttled down by closing the throttle, the air cannot enter in such a large quantity, and in consequence there is a decided vacuum in the cylinder on each intake stroke of the piston. This vacuum has a tendency to draw oil up past the piston into the combustion chamber, where it burns and forms smoke. This is why, when the machine is left at the curb with the engine running for any length of time, it will often be found to start away with clouds of smoke issuing from the exhaust.

In the same way, when the engine is running slowly, air passes through the carburetor so slowly that the gasoline is not broken up into very fine particles, consequently it does not fully vaporize and is very easily condensed. It forms liquid gasoline in the intake pipe or cylinder. This is called "loading up" and is responsible for black smoke when the machine is started.

One way of overcoming this is to supply a larger amount of heat than usual to the mixing chamber. Most carburetors are not designed to take care of this condition and the only remedy would be to stop the engine instead of allowing it to run while standing at the curb.

To overcome smoke from the oil which is drawn up past the piston, it is customary to have a groove turned in the piston under the lower piston ring, with five or six holes drilled in the groove through the piston. The piston ring then scrapes the oil from the cylinder wall into the groove and it is led back into the crank case through the piston walls. This prevents it from working up into the combustion chamber. Many manufacturers have this scheme on the very new models and repair men are using it on older models which were not turned out with it.

Sometimes the oil level will be found too high. This may be corrected often by lowering the oil troughs, or by filing off the dip on the bottom of the connecting rod so that it touches the oil with a narrowed surface.

In addition to the smoke resulting from too much gasoline or oil there is a large amount of carbon deposited in the cylinder which takes up space in the combustion chamber and raises the compression so high that pre-ignition occurs and the engine knocks. The car must then be taken to a repair shop to have the carbon burned or scraped out. This is expensive work and besides the car is laid up and one loses its use while the scraping is being done. The owner will see that he has been spending a lot of money to supply gasoline and oil that he didn't need to use just to make smoke and carbon and expense and that he has lost from every point of view.

Smoke should not be confused with steam which issues from the exhaust pipe in cold weather. One of the products of combustion in the gas engine is water, a natural result of the breaking up of a hydro-carbon. This usually passes off at a high temperature as an invisible vapor. In cold weather it condenses immediately it strikes the air and is visible in the form that we call steam. Really it is a fog that we create. Therefore do not let the policeman summons you for having a smoking engine, when it is only steam issuing from the exhaust pipe. If he doesn't know which it is you probably can convince him, by the color. If it is white it is steam, if it is black it is gasoline smoke, and if it is light blue it is the smoke from the lubricating oil. Therefore watch your exhaust for there are many eyes watching you just now in parks and city streets.

CHAPTER IX

THE CARBURETOR AND ITS FAILINGS

ONE of the frequent and most annoying troubles to which automobile engines are subject has to do with the carburetor. With one of the standard carburetors or vaporizers which is properly adjusted there should be, and usually is, no serious difficulty in ordinary conditions, but if there is one part of the engine which seems possessed to kick up its heels it is the carburetor. Particularly is this so in the frosty months, when the gasolne and air do not mix properly and do not vaporize when they do mix. This is of easy solution, however. Simply warm the intake a few minutes and it will take care of itself thereafter.

In these days of indifferent gasoline automobile drivers are complaining constantly that the carburetors are giving unusual troubles. The carburetor is the lungs of the engine. Well, did you ever breathe in a crumb of cake and then for a while have all your faculties suspend operation while the lungs sought to expel the intruding substance? That is just what happens when you get a crumb of something in the needle valve, or in the intake valve of the vaporizer. One little, good-for-nothing, insignificant speck of dirt, so small as to be almost invisible, will put the best carburetor literally out of business, and the only thing to do is to remove the speck.

There are several good makes of gasoline strainers which reduce this trouble to a minimum, provided one will drain off the strainer occasionally to let the dirt run off. Straining the gasoline supply through wire gauze or chamois does not obviate the difficulty, for gasoline tanks are prone to acquire a slight sediment.

A few drops of water in the gasoline which reaches the carburetor will make trouble likewise, for it will not vaporize, and, what is more, it will not let anything else vaporize. Probably no one is trying to dilute the gasoline with water and sell you such a mixture, but there are some mighty careless men in the gasoline trade. It reminds one of the farmer caught selling watered milk, who pleaded that there was a pump in the milking yard and some of his men must be careless in passing by it. The chamois skin will remove this impediment, for water will not pass through it.

Another trouble which afflicts motor-boat engines more than the automobile motor has to do with the weather. The motor-boat carburetor requires frequent adjustment, due to changes of the weather. On a dry, warm day the gasoline vaporizes easily and the maximum charge is readily exploded in the cylinder, giving a maximum of power. On a wet, cold, heavy day, one must slightly decrease the supply, or the cylinders will clog, the engine will knock, and one will think harsh things if they are not audibly expressed. The automobile engine, not being so constantly over the water, will not have this trouble so much, but it is probable that most drivers fail to take this into consideration and perhaps do not know that it is a cause of trouble.

A very slight leak in the intake manifold gaskets likewise makes all sorts of trouble, since the supply of mixture to the cylinders will vary according as the vibration opens up the gasket and stops the suction by which the cylinders are supplied. A leaky piston ring will do this for one of the cylinders. If worn, or frozen fast by carbon, it will fail to keep the piston tight, the mixture passes by the leak, if sucked in, and there is no compression and no explosion or irregular firing. This will make one think sometimes that the carburetor is at fault, whereas the engine really needs an overhauling.

In fact, if one is having engine trouble which is hard to diagnose, one should try out the piston rings to see if they are doing their duty. This is very simple, for all practical-test needs. Crank the cylinder up to high pressure and let it stand a couple of minutes. Then open pet or priming cock and see if there is any pressure left. On the two-cycle engine this is a good test, and by trying the cylinders in turn piston ring trouble may be located.

On the four-cycle engine the valves must be considered also, for they may leak and the pistons be perfectly tight, but in such an event it will be found almost impossible to get good pressure on the cylinder, since it leaks through the valves while the piston is making the compression stroke. Don't condemn the carburetor until you have determined whether either of these things is occurring.

The carburetor should be drained occasionally to prevent the accumulation of sediment, which will later clog the needle valve, and at least once a season should be taken apart and cleaned. Time spent in this way well repays the owner.

In all that has been said thus far no account has been taken of poor gasoline. By this is not meant gasoline with water or dirt in it, but a poor quality. Nowadays there is such a demand for gasoline for automobiles and motor boats, that the producers have had to market much of a low grade, or, as is generally the case, have mixed the first quality with the cheaper grades, producing a medium quality.

The seeming necessity of utilizing these low grades of gasoline makes it necessary to change the carburetor forms, and one sees now a tendency to do away with the old, long intake, either by raising the carburetor to the cylinder level, with a horizontal intake only, or with an internal intake manifold, the carburetor being attached to the cylinder block. Several makes of carburetors using one of these methods are said to vaporize even the low grades of gasoline, while some later models are claimed to handle kerosene successfully.

For the motor boat there are several makes of vaporizers which will handle either gasoline or kerosene, and all intermediate grades, by slight adjustment. It is possible that some ingenious builder will devise a similar vaporizer for the automobile engine, if gasoline continues to decline in quality, and to be short in supply as well.

An easy test to see whether the carburetor is working right is to run several blocks with the throttle practically closed, then, when the road is clear, press sharply upon the accelerator pedal, which opens the throttle wide and should make the engine speed up and the car jump forward. If it is sluggish it will denote a too rich mixture, and if it sputters and perhaps backfires, it is too lean. But if, with smooth yet rapid action, it makes the car speed up, that is "pep." The amount of pep which a car is said to possess is gauged by the quickness with which it responds to the acceleration, either by the pedal or by throttle lever, changing the car from slow or moderate speed to full speed. That, too, without jerky action or tearing the motor apart.

While this test, showing the presence of pep, will denote that the mixture passing through the carburetor is correct, absence of pep does not always mean that it is wrong. Therefore it is not wise to jump to the conclusion that the adjustment is wrong. In fact the adjustment should not be changed unless it is fully certain that it is wrong. If the car has been running with the carburetor working properly and no one has changed the adjustment, it may safely be assumed that the carburetor adjustment is correct. Adjustments are not changed except by someone's fingers.

Do not be like the new chauffeur who, having trouble, at once descended upon the carburetor. Another chauffeur whose car was standing near advised:

"I wouldn't touch that, boss."

"Well, there's something the matter and I guess it's here," said the troubled one.

"I wouldn't touch it, boss; try somewhere else."

"Oh; let's see what's on the inside of it," impatiently exclaimed the new chauffeur, and he proceeded to unscrew and unbolt the parts.

Of course, he had to send to the garage for a repair man and finally was towed in for complete reassembly and reajustment of the part.

The lesson in all this for the owner is that he should learn the make-up and peculiarities of his carburetor, understand its common and uncommon ills and thus be able to remedy a trouble which would mar a trip or the general serviceability of the car. It is unnecessary to go into the detail of any make of carburetor, because if the manufacturer's instruction book does not contain full information and sketches of the make used, a special carburetor book may be obtained from the maker. But there is no excuse for failure to master the lungs of the engine and to learn how to keep them breathing properly.

CHAPTER X

GETTING THE MOST OUT OF A GALLON OF GAS

WITH the price of gasoline constantly mounting skyward and tires following when not leading the rise, while everything else needed for automobile upkeep is ascendant, it is timely to assert the need that the owner consider his expense and renewal costs. And when it is considered that labor and repair parts have pirouetted along with the other things, it behooves the owner to devise ways of decreasing his running expenses and to learn how to get as much as possible out of a gallon of gas, and every mile out of his tires they can be coaxed to give.

There are many little expenses about running a car which total a considerable sum. A nickel, a dime, a quarter, a dollar, do not seem much at the time, but they pile up the cost per mile frightfully. Not everyone can be like a friend, who, when cautioned about the way his chauffeur was running up the cost of his several cars, replied:

"I don't want to know what my cars cost. If I did, my business instinct would doubtless make me dispose of them all, and I do not want to do this. The cars are a luxury and I don't want to know what they cost."

A car which lasts with ordinary care one or two years, if given intelligent care by the owner might be made to last three to five years. This means taking unusual precaution and having a thorough knowledge of the working parts and of how to keep them in condition, and it means doing faithfully and persistently the things necessary to keep everything in order.

When it is considered that under prevailing conditions it may not be possible to get a new car as often as it has been in the past, it might be as well to take care of the cars we have rather than let them go to rack and ruin for lack of care. A good many automobiles are wasted more than they are used. In some cases this is due to carelessness and in others by lack of knowledge of what to do and how to do it.

Take tires, for instance. The cost due to neglect is often greater than the cost of actual wear. Some of the things which cause excessive wear and deterioriation of tires are driving into holes in the street, or in deep ruts, turning corners at too high speed, stopping the car so quickly with the brake that the wheels slide on the pavement, and a harsh clutch which jerks the car suddenly from a standstill, causing needless wear. Then there are such things as letting the front wheels get out of alignment so that they do not run parallel, or nearly so, the action being that the tire is slid, instead of being rolled, over the road. There should be a slight toe in, for mechanical reasons, as explained elsewhere, but if this is allowed to go beyond the proper limit it costs money.

Adjusters tell us that a very large percentage of tire failures is caused by under-inflation, which allows the tires to flatten and breaks the side walls. Every tire should be tested with a gauge and not with the eye or hand and kept to the pressure named by the tire maker.

To get the greatest life out of a tire it should be watched continually for small cuts through the rubber to the fabric. Most tires will be found after a short service to have from two to a dozen such cuts. These will allow sand to work in and loosen the rubber and then moisture gets in and rots the fabric. There are preparations with which these cuts may be healed in a few minutes; serious cuts, especially where the rubber is loosened from the fabric, should be taken at once to the vulcanizer.

While oil and grease of good quality cost money, their proper use will save many times their price in replacement of parts. On the other hand, a waste of lubricant makes unnecessary expense. Especially with a new car, oil and grease should be carefully watched until the bearings have had time to work in. That is the time when expense for replacement of bearings is most likely.

It is not generally realized that a large number of things enter into the economical use of gasoline. To get the most out of a gallon of gasoline all moving parts must work properly. This means proper lubrication. The brakes should not drag; each cylinder of the engine should fire properly; the clutch should not slip, and the carburetor should be in proper adjustment. It is not well to adjust the carburetor unless you are sure it is at fault. Excessive carbon in the cylinder causes a decided loss of power, due to back pressure on the piston, and the partial clogging of the muffler indirectly consumes extra gasoline. The importance of keeping the muffler free is not usually understood.

To insure each cylinder getting its proper power without waste, the engine should be driven with the spark lever advanced as far as possible without causing back pressure. The spark-plug gaps should be properly adjusted to insure a thorough ignition of the charge; the spark plugs should be kept clean to prevent the loss of a charge of gas through non-ignition, likewise the interrupter points, and the distributor should be kept clean and properly adjusted.

To use all the gas that is taken into the cylinder there should be no loss of compression through leaky valves, or weak valve springs, or poor gaskets on spark plugs or valve caps; and it is equally important that pet cocks, cylinder head, where there is one, and piston rings are tight, so that gas will not be wasted.

It is not safe to leave these things to the chauffeur and the garage man. The owner should learn himself how to make all these adjustments. If he does so he will find that his propelling machine will work better, and that he will not only have more use and pleasure out of it, but he will save a very appreciable part of the cost of up-keep.

CHAPTER XI

THINGS WHICH MAKE GAS BILLS HIGH

THERE are other things which affect the amount of gas consumed which need the attention of the automobile owner. One of the common things, mentioned in the preceding chapter, concerns the intake manifold, which has to do with the distribution of the gas mixture from the carburetor to the several cylinders. A leak at the carburetor side would prevent drawing into the manifold a sufficient supply of the mixture, so that the cylinders would be scantily supplied—perhaps one or more not supplied at all. Likewise air would be drawn into the manifold through the leak, and this would thin the mixture coming from the carburetor. As the mixture in the cylinders would be thin it would not compress properly, the firing pressure would be poor, the mixture would fire badly or not at all, and the power would be lessened.

The natural thing to do when the misfiring is noticed is to open the spray or needle valve, admitting more gasoline to the mixing chamber and making a higher consumption with no gain in power. The proper thing to do, however, is to look for a leak in the manifold.

If the leak is on the cylinder side of the manifold, it might be at one or all of the cylinders. The result would be the same as in the case just cited, a poor supply of the mixture, or some of the cylinders might be properly supplied and work all right, while others might be short of the mixture and might not fire at all. The loss might be sufficient to affect seriously the power and lessen the speed of the car.

The manifold ought not to become loosened in the ordinary use of the car. There have been cases where vibration has done it, but the usual trouble is where the manifold has been removed for some purpose and improperly replaced. Copper and asbestos gaskets ordinarily are used, and these may be dented or jammed out of shape so that the joint is not tight, or there might have been no shellac handy, or the bolts may not have been tightened enough. Whatever the reason, the leak makes a weak mixture, and the first thought of the chauffeur or the average garage man is to increase the gasoline at the spray nozzle of the carburetor to make the mixture of the right proportion to fire. On account of the mixture being made in the intake manifold, instead of the carburetor, as it should be, the work is not efficiently done and gasoline is wasted, the result being the increase of the expense account.

One of the most common causes of gas loss is from leaky supply pipes. Where there is a solid pipe from tank to carburetor the only leak, barring a break or perforation of the pipe, would be at the connection with the tank or the carburetor. Vibration might cause the joints to loosen, though if they are put together properly with shellac, soap or some equivalent, and are thoroughly tightened, there ought not to be any loosening. It is needless, but how often we see a car dripping gasoline at considerable loss. It is also dangerous, for a stray flame or spark may ignite the gas.

There is another leak of the same nature which is quite as expensive, and that is of lubricating oil. If you do not believe it to be prevalent or serious in extent, you have only to watch places where automobiles stand frequently along the curb and notice the pools of oil on the pavement. These come from leaky crank cases, transmission gear cases, rear-axle gear (differential) cases, or from a faulty distributor. In most cases it is only a matter of tightening a few bolts or connections occasionally;

but with oil at present prices it is a serious matter.

Another leak which needs to be corrected frequently is at the valves. So much has been written about the care of valves that it would seem superfluous to refer to it, but regrinding and proper care pay big dividends in efficiency and should be on the regular program. There is a leak at the valve, however, seldom mentioned, though quite as serious as the others, which is due to worn valve stems.

The valve stems should fit snugly in the guides; if they do not, air will be drawn past the stem into the cylinder on the suction stroke and thin down the mixture so that the engine runs irregularly, unless more gasoline is supplied at the spray nozzle, and throttling down to a reasonable idling speed is impossible. If the exhaust valve guide is worn there will be a hissing sound that is objectionable.

The purpose of repeating this caution as to mixture thinning is to make it plain that wherever there is a leak between the carburetor and the cylinder it lets in air and thins the mixture so that it is necessary to feed in more gasoline to get a mixture that will fire and that is wasteful, for a mixture made anywhere else than in the carburetor is less efficiently accomplished.

The burned gases pass out through the exhaust valve side and in so doing often deposit small pieces of carbon, which keep the valve from seating properly and let perfectly good mixture escape. If not cleaned often, the heat and constant tapping of the valve against the seat will hammer the carbon fast to the valve or seat as though it had been fused there. Carbon must be scraped off frequently and as often as necessary the valve should be reground into the seat.

Piston rings which are not pinned often work around until the slots are in line and the mixture will blow through. If the rings will not stay in place a pin should be put in the ring groove on the piston to prevent the ring from working around and the slots should be staggered, so that no two are in line. Naturally the rings must be kept free from carbon or gum from the oil or they will freeze to the groove and leak mixture.

In older cars the cylinder may be worn oval, so that the piston and its rings do not fit. When the cylinder is oval the piston will not pump in the mixture properly, and when the explosion occurs much of the burned gas will be forced down into the crank case. One of the products of combustion is water, which is exhausted in the form of vapor. When it gets into the crank case and condenses, forming water, it collects under the oil. In cleaning out and replacing the oil, if water is found, it always indicates a tendency to oval in the cylinder. This is caused by the thrust of the connecting rod being against one side on the up stroke and against the other on the down stroke.

With everything else there may be a loss of gasoline by reason of poor adjustment of the carburetor. The adjustment should be such as to make the mixture as lean as possible and have it fire readily, and to have the float not too high. One sure indication that the mixture is too rich is when black smoke is given off. Black smoke always indicates excess gasoline—burning money. As has been told in another chapter, there is another kind of smoke to guard against, but if the owner will make sure that he is not exhausting black smoke he need not worry about the price of gasoline, and a little judgment and care will eliminate many of the items of upkeep expense.

CHAPTER XII

CARE OF THE TIRES

When a tire buyer is told by the dealer that a tire is guaranteed for so many miles, the manufacturer expects to make good—he expects if the tire falls down on performance to replace it, or at least make an allowance for the mileage short. As a matter of fact they do not have to do this on thousands of tires which are defective, for the reason that the auto owner has not kept his part of the bargain. Nine times out of ten this is because the user of the tire does not know how it ought to be treated and doctored and cajoled into doing all that it is expected to do.

Tires are a great deal like human beings; are just as finicky and contrary; and it takes a great insight into their make-up if one would get the most out of them.

One of the chief causes of tire deterioration is lack of care—absolute neglect. Drivers send their machines over all kinds of roads, regardless of ruts, and stones, and glass or junk in the roadway, and then cannot understand why the tires are all cut up about it. Worse than that, they do not seem to understand that a cut tire needs as much and as prompt attention as a cut finger—perhaps more, for nature will mend the one; the other has no such luck.

The first thing to do when one discovers a cut is to clean it out and jiffy in one of the good solutions sold, which will cement the edges together or press in the putty-like repair material. If the cut is not too large or too deep it will mend easily and give little trouble, if care is taken. If it is a large cut the vulcanizer should be visited. The cement should hold long enough for that. It will keep out water, which rots the fabric easily, and sand, which makes blisters along the tread. Only a slight patch is needed if done promptly, but if water and sand get in it is almost impossible to vulcanize in a patch, and when it is done it probably will not last.

Tires should be inspected regularly and often and attended to intelligently. This will save the automobile owner much annoyance and cut down one of the big items of maintenance.

Some drivers, too, never seem to think of favoring an auto tire at times of greatest strain. They will whirl around a corner as fast as their nerve and the traffic policeman will allow and then wonder why it is that the tread wears away so quickly. They do not seem to understand that under such circumstances there is a steady grind of tire upon pavement, and grind means wear.

Another set of drivers will run along for weeks without noticing that the steering gear is out of true. Perhaps the machine has hit something and the equalizing rod is bent just a trifle, making the front wheels far from parallel. It may not be enough to see with the eye, but it is off true and one or both of the tires grinds with every revolution. The speed with which the tread will wear away depends upon the character of the roadway. On gravel or macadam roads it is fast. The manufacturer will not replace a tire worn out that way if he can detect the cause, and experience has taught him where to look for it. One man wore a pair of front tires through to the fabric in a very short run and raised a fuss because the replacement man disclaimed reponsibility after testing the wheels. The roll and slide motion combined will work havoc with the best tire and should be corrected.

A harsh clutch does the same thing in a little different way. A clutch which grips too hard will cause the wheels to slide and wear. The brake, also, should not be too positive, but be adjusted to work easily, so that the wheel will stop turning just as the momentum is spent, to prevent sliding. Both brakes should be adjusted alike, or one will grip the wheel fast and the other turn. The gripped tire will scrape along and the pavement cuts the tire like a rasp.

Another set of men forgets that oil and grease and gasoline are the natural enemies of tires. They allow the machine to stand in the garage where there are pools of oil or gas. Gasoline will dissolve gum rubber. It will disintegrate the tire, which is a combination of rubber, soapstone, and other things, so that it wears out quickly. Lubricating oil and grease hasten the decay of rubber and shorten the life of the tire. Besides there is no sense in wasting oil and gas, and if someone else allows it to spill on the pavement the wise man will keep out of the mess.

In wet seasons there is especial need for care of the tire. Rubber cuts easily when the sharp edge of the cutting agent is wet. Tire workers dip their knives in water to facilitate the work. Go out on a road where there is glass, or sharp stones dripping from a rain, and the tire is an easy mark.

A wet day on a sharp gravel road will fill the tires full of small cuts.

Tubes should be kept in the shoes where possible. If folded up they are likely to harden on the creases and crack on the surface, blowing out easily. Tubes in excess of shoes carried should be rolled up carefully and be kept in a bag to prevent chafing on tools or box.

Tires cost the owner about the same as the car if he does much running. In a general sense the set of four tires used on any car bears a certain proportion to the selling price of the car. On the cheaper makes of cars the tires cost new approximately \$60 per set. They increase in price in direct ratio to the price of the car. They are usually guaranteed for five thousand miles, and as the average owner makes at least ten thousand miles per year, he uses up two sets of tires. Taking three years as the average time the owner will keep the car before trading it in, would mean six sets of tires. Taking the car which uses the \$60 set and we find that six sets of tires would cost \$360, or pretty near the first cost of the car. Few owners give consideration to this fact.

Another way of figuring the cost of tires is that in upkeep expense tires figure for one-third of the total, gasoline and oil for another third, and wear and tear on the car the remainder. Upon this basis the owner should give one-third of the total care to the tires. But few, if any, do.

When the car is stored for the winter, or for any length of time at any other season, the car should be jacked up and the tires deflated until the pressure is less than half the normal. Where the car cannot be left jacked up the tires should be removed from the car and hung up high and dry where there will be neither extremes of heat nor cold, though heat is more injurious than cold.

It is good practice, if, on coming to the garage, it is found that one or more tires are deflated below normal and there is no time to pump them up, to lift the weight off the tire with jack or otherwise, so that the strain will be removed from the walls of the tire between the rim and the floor or ground.

Do not put tires where they will be subject to strong sunlight, which decomposes the rubber. Oil and grease left on the surface do the same thing. Clean the tires of mud and grease after every trip. Keep the small cuts healed and the big blisters will not occur.

Make friends with the vulcanizer and take his advice as to repair of your tires. That's his business. If too far from a vulcanizer, buy a small outfit and spoil a few casings and tubes learning how to do the small jobs, and send the big ones to the shop by express.

Remember in mending tubes and casings that cleanliness is before godliness. You may be a perfect church member, but if you do not observe perfect cleanliness the mend will not stick and in the end may lose you your church membership by provoking you to violent words.

Throw away the valve insides every once in a while on general principles and put in new ones. Learn how to test the tubes by dipping them under water when inflated and looking for air bubbles. Test the valve the same way, at the same time. Bubbles may indicate why the tire will not keep pumped hard.

Rubber is porous to a slight degree and you must expect loss of air from that cause both in the tires on the wheels and that held in reserve. Make sure of the pressure by the tire gauge.

CHAPTER XIII

SKIDDING MAY BE MINIMIZED

WHEN you are out driving next time watch the cars ahead of you and notice how many of them have wobbly rear wheels. You can by this means tell fairly well who is a careful driver and whose car has been skidding about the streets and has brought up sharply against the curb, or car track, or rut, or some other obstruction over which the wheels would not slide, and which was sufficiently solid to give them a hard knock.

No man can appreciate what a skid means until he has had one and then, perhaps, he will not live to appreciate it. No amount of preaching seems to do any good. He must sow his wild auto-driving oats and learn from experience. Because of this, it is recommended that each driver who has not had a real skid yet, pick out a very broad and wet street paved with asphalt where there is no traffic in sight. Let him drive the car fifteen miles an hour up the middle of the street, then give the steering wheel a sharp turn to the left, at the same time applying the brakes. The resulting sensation of absolute helplessness will be remembered for an hour or two—at least. For those who wish to continue the lesson, try allowing some other driver to repeat the operation, while the experience seeker occupies the back seat.

Now the skid against the curb or other obstruction may not have demolished the wheel, but it left its mark in cracked spokes, or bent rim, or if the car was of a certain type of construction it may have bent the axle shaft itself. If the wobble is due to a bend in the rim, it wears the tires excessively and if the spokes have been a little cracked it weakens the wheel; if the axle shaft has been bent, it is causing undue wear in the bearing; and under all of these conditions there is too much wear of the tires.

During the winter skidding is prevalent, much more so than at other seasons. This is due to the fact that snow and ice keep the pavements wet or icy, according to the temperature. There is another element entering into the situation, however; most folks who travel at this time of the year, because of the cold and discomforts of motoring, desire to get there and so travel faster—the very fact that they are uncomfortable causes them to pay less attention to driving with care. The result is that they run up close behind some other vehicle, which stops quickly; then they jam on the brakes hard and skid. Or, a car comes out of a side street suddenly, making it necessary to swerve quickly to one side, or stop, and the result is a skid in either case.

A rather unusual case of skidding is thus related by a driver:

> I was driving up Broadway, in New York City, and to make the hill north of 157th Street had put on a little more speed, for the car was not a good hill climber. A block or two above the subway station a boy on a sled darted out of a side street and swung to continue down the Broadway hill. To avoid hitting him I jammed on the brake hard, and began to skid. There was a wagon at the curb and on the other side of me an auto going in the same direction and there was not room to turn out.
>
> I saw that if my car continued to skid it would swing in front of the sled. It is unusual to skid going up hill, but there was so much loose snow, with ice underneath, that the skid chains did not take hold. There was but an instant to act, much less time than it takes to tell it, and I released the brake and let in the clutch. This stopped the skidding and the car shot forward just in time to let the boy go by.

Probably the greatest cause of skidding is turning the corner at too high speed. This often causes a skidding of the front wheels as well as the rear wheels—that is, the car is going so fast that the front wheels do not get traction enough to change their direction and when they attempt to make the turn they skid and the car goes for the curb. Applying the brake usually will overcome this skid.

In a rear-wheel skid the worst thing one can do is to apply the brake. It is best to let the car coast, turning the front wheels in the direction in which the rear end of the car is skidding; if it is trying to go to the left, turn the front wheels that way. If there is something in the way, so that it is necessary to stop, the brake may be applied a little as the wheels take hold, leaving the clutch engaged, which prevents locking the wheels, as the engine is pulling against the brake and there is not so much danger of locking the wheels. It keeps the wheels revolving slowly, so that you get a better traction for stopping.

It takes a greater pressure applied laterally to start the wheel sliding than to keep it skidding once it is started, and you can bring the car to a standstill much quicker if you can keep the wheels from sliding. A little practice will teach the driver just how much he can apply the brake without causing the wheels to skid.

The bent axle has been mentioned as a result of skidding. It may also be a cause for skidding, for it sometimes happens that by hitting the curb hard, or the wheel of another car, or a street car, the rear axle gets out of true—perhaps the spring-seat bolt will shear off—and the wheels will not track with the front wheels. This will cause skidding.

When there is not snow during the cold months, often water is used to sweep or flush the streets. Wet asphalt is always slippery, whether it is warm or cold, but in cold weather it often freezes and the pavement is dangerous and skidding is almost certain unless care be taken. The street-car tracks are another cause of skidding. Often it is necessary to give the front wheels a considerable turn to get out of the track when necessary, and, especially if they are wet—and they are wet when other parts of the pavement are dry—the rear wheels will continue in the tracks, causing a bad skid. Under no circumstances should one habitually drive in the car tracks when the streets are wet.

If the brakes are adjusted unevenly, so that there is a little more pressure on the one wheel than the other and therefore stops it a little more, it will cause skidding. Another case may come from giving the steering wheel a little twist just as the brake is applied. Occasionally in an emergency stop the driver will give a hasty glance behind to see if a car is close upon him. The hands follow the eye, it is said, and this will often give the slight twist that causes the wheels to slide.

Some cars skid because the weight is not balanced on the wheels—that is, there is too much weight on front or rear wheels. There is a remarkable difference in cars in this respect and it might be well before buying a car to try it out on its likelihood to skid.

There are numerous designs of non-skid tires and they do prevent, or decrease, skidding to a very large degree on some cars. While they help in some cases, it is not well to depend upon them entirely. It is the general practice now to use non-skid chains. On muddy roads they are a necessity and on wet asphalt are almost as essential and chains should be used under such circumstances; but as they cause excessive wear on the tires, they should only be used when needed. The driver should not allow himself to be either too hurried or too lazy to put them on and take them off according to the condition of the pavement. Better to do this a dozen times a day rather than wear out a set of tires or skid into the curb or a street car.

They should be adjusted loosely, so they can creep around and wear the entire circumference of the tire slightly but evenly; if they are so tight they cannot creep, the cross chains will cut away the outer rubber right down to the fabric. A great many tires are ruined in that way. Tires cut this way cannot be turned back to the manufacturer for replacement, for the adjuster will know at once what caused the wear.

Be sure there are a sufficient number of cross chains so that it will not be possible for the brakes to stop the wheel between the cross links, for in that event it will slide just as badly as though no chains were used. As a car is more likely to skid going down grade than on the level, it follows that extra care should be exercised, and that the driver should slow speed for a stop farther away than would ordinarily be necessary, and that the stop should be gradual. One should watch closely on a hill, for there is a greater coasting momentum and a greater tendency for the rear wheels to slew around, because of the weight upon them.

After all, the greatest preventive of skidding is care. The driver who keeps his eyes and wits about him will have his car under control in situations which might possibly cause skidding. It is an essential of economy in tires and wheels and some other parts of the mechanism, and it is an essential in safety, for some very bad, even fatal, accidents have come from skidding at an unfortunate moment, when care would have prevented it. It is no fun to incur injury to person or car, or to pay for repairs or excessive renewals; he who would avoid causes for much of this should beware of skidding.

CHAPTER XIV

"CAN'T-SLIP HEELS" LESSEN SKIDDING

If your auto is not equipped with "Can't-Slip Heels," the green or pink plugged shock absorbers, the same as you wear on your own heels to keep from skidding over the sidewalk, perhaps it were well to look into it a little. Autos as well as men take to skidding quite easily, and not infrequently come to grief.

We use rubber heels to absorb shocks and jars just as we use rubber tires on the auto to absorb road shocks. We find in both instances that in wet weather the pavement becomes lubricated and a slip or skid is likely to result in damage to person or car. In the case of rubber heels it was found desirable to provide some means to prevent slipping, and plugs were inserted which grip the ice or slippery surface and hold fast. Tire manufacturers have developed all sorts of devices, such as projections and recesses, vacuum cups, etc., in the tread of the tire, to keep them from slipping. In one case the device has been very successful, where the manufacturer has inserted strips of cotton fabric in the tread of the tire, on the same principle as the plug in the rubber heels.

The fabric, really a thick canvas, projects a very little beyond the rubber surface, and gives the tire a better traction than plain rubber would have on a slippery pavement, and makes one of the best non-skid combinations. You doubtless will remember that rubbers worn smooth are more slippery than the leather heels with their nails; or that the rubber heels which have no plugs get very "slick" and are worse than nothing. It is exactly the same with rubber tires.

No matter with what non-skid device tires are equipped, there is always the danger of slipping when the pavements are wet or slushy, and the fact that such equipment is used should not make the driver think that he can drive at high speed with safety. On ordinary wet pavements very satisfactory results are obtained with most of the regular non-skid types of tires. Where ice or packed snow or surface mud is encountered, chains are better. In very deep mud, loose sand, or loose snow, heavy rope wrapped around the tire between the spokes will probably be found best.

In an emergency, when caught out in the country, it might be necessary to cut up a blanket or find some other substitute for the rope.

When there is a telephone pole or post near at hand when the car becomes stuck in loose snow, sand, or deep mud, often the car may be pulled out if a tow rope long enough is handy. Fasten one end of the rope to the pole and the other to the forward part of the rear wheel. Then start the engine and if the rope is strong enough and it is stretched tight enough, as the wheel revolves it will start the car forward. Take a fresh hitch on the pole and try it again. A few inches at a time it will pull the car forward, a distance equal to about the diameter of the wheel, and in time get the wheel out of the rut or hole so that it may grip the solid earth again.

The flat steel stud tires are absolutely worthless on ice; they are good skates, but for gripping the ice they are failures.

The great majority of skids are due to excessive speed. The author has been told by a driver who drifted into another car and broke both headlights that he was only going ten miles an hour. This was probably true, but unquestionably he was going too fast for the condition of the streets and his tires. It is quite necessary that the driver should know how his car is going to behave under all conditions and drive accordingly.

Occasionally the crown of the road will cause a slip of front or rear wheels to the side that cannot be prevented by a reduction in speed; but the careful driver will at least drive slow enough under such conditions to make whatever damage might occur from this cause as light as possible. Whereever a road has a crown there is always increased danger of skidding, but often these roads that have a hard slippery section in the middle have a narrow strip of gravel or dirt on each side. Where this is the case it would be better to drive with one pair of wheels in the dirt rather than to keep in the middle, where slipping is almost unavoidable.

In other cases, where there is no dirt strip, it is perhaps better to keep right in the middle of the road and to use great caution in turning out for other vehicles.

Rounding a corner at high speed is, of course, a direct invitation for a very serious skid. Making sharp turns of the steering wheel on straightaway is also dangerous. When driving in traffic on slippery pavements, care should be taken not to follow another vehicle too close and to judge stops far enough in advance so that the car may be brought to a standstill, if necessary, several feet before the desired point is reached. In other words, the brakes should be applied very carefully.

In extreme cases it may be found impossible to apply the brakes at all without skidding, and it will be necessary to practically allow the car to drift to a standstill. Brakes which are adjusted so that one takes hold a little stronger than the other will also cause a skid, by permitting one wheel to turn and twist the car about.

When skidding does occur, about the only thing the driver can do is to turn the steering wheel in the direction of the skidding, with no pressure on the brake. This will correct the skid before damage is done, provided the speed is not too great. Another help in preventing skidding is to leave the clutch engaged and the engine pulling slightly when the brake is applied. Of course, before the car is actually brought to a standstill the clutch must be released, or the engine will stall. The slight pull of the engine when the brake is applied prevents the locking of the rear wheels, and in that way prevents skidding in a large measure.

On any stormy day a short tour of any of the much used avenues in any city will disclose a variety of machines which have had their skid and are against the curb with broken wheels, if nothing worse. It seems as though no amount of advice will teach the driver to use care on slippery pavements. He must have his own skid before he learns his lesson.

The season for skidding is always with us, however, and every patch of ice, or a frozen or wet street surface, or a muddy country road gives the warning "Drive Carefully." It behooves the owner, therefore, to provide his car with the best safety devices to be had, whether it be chains, rope, tires with plugs which encircle the tread, or whatever may be necessary. He will do this if he has had his skid; if he hasn't, probably no amount of advice will have the slightest effect upon him.

CHAPTER XV

AVOID NEWLY OILED ROADS

TOURISTS going out on week-end trips into the country, and country owners who go into strange sections, should pay strict attention to signs which say in effect: "Danger, Road Being Oiled." It does not matter in the least whether you believe in signs or not, pay attention to all such; it may save an upset, or at least skidding into the ditch. An oily macadam road is more slippery even than a wet asphalt pavement.

The danger is greater from the fact that the road is crowned—that is, it rises in the center and slopes off on either side to a ditch. If you get off the crown on an oily road the machine is pretty sure to slide toward the ditch. In running over an oily road it is necessary to keep on the crown as much as possible and when one has to pass another vehicle, if he cares much for his safety, he had better slow down, or come to a stop, and let the other fellow worry about getting by. An ounce of caution before is worth several horse-power of energy in getting the car back after it goes in the ditch or tries to climb a telegraph pole.

Recently the author had occasion to visit Orange County, New York, and struck a piece of very heavily oiled road near Goshen. It apparently had been oiled the night before and the workmen had not finished putting on the binder. It was thick with oil. The road makers knew it was dangerous and put up a sign similar to that quoted above, but a big car ahead went down a little slope leading to the oil and the driver failed to heed the sign quickly enough, and when we caught up with him he was in the ditch. Coming up were half a dozen other cars sliding all around but trying to get to the ditched car to give assistance.

The big car had slowed down somewhat, else it would have gone over into the field, but it had turned completely around and was headed in the direction whence it had come. The other cars were sliding in every direction. When he found his car beginning to slide, the author very cautiously stopped, for his car was just moving. On inquiring of the driver of the skidded car, he was told that when the latter had found himself skidding around he had jammed on the brake, and, of course, just as might have been expected, the rear of the car went right around. In going up the slight rise of ground, the author met other cars and had to leave the crown of the road. Immediately the rear tires began to slide and he went for some distance with the rear pair of wheels trying to slide down into the ditch while the front pair were holding fairly well to the road. As soon as he could get back on the crown of the road again, of course the car straightened out all right.

Any car which struck the oiled road on high speed would have turned over or smashed against a telephone pole and probably everybody aboard would have been hurt, if not killed; so it is wise not to be so absorbed in entertaining one's friends that warning signs are missed.

CHAPTER XVI

WATCH YOUR BRAKES

LOOK well to the condition of the brakes on your car before starting on a trip. See that they are in good shape even if you do not have time to look over the engine. The brakes are more important than the engine. It needs an engine in at least fair condition to get anywhere, but if you do not have brakes you may get too far—too eternally far.

Manufacturers of cars have recognized the importance of the brake appliances and have given considerable attention to the improvement of the brake, designing more efficient operating mechanism, increasing the size of the braking surface and improving the quality of the friction materials, and also in protecting the brakes from excessive wear due to grit and dragging of bands when not in use.

The brakes, moreover, on the average car of modern design, are sufficient for all general use, if used intelligently and if they are given a moderate amount of care. But like most other parts of cars, some owners give them no attention whatever, and consequently there is frequent failure and often it is a matter of life and death when the brakes refuse to work properly.

First of all, owners should understand that there are two sets of brakes on the car, which operate independently of each other, and each brake should be capable of holding the car at a standstill on practically any grade, or, as the chauffeur usually puts it, "sliding the wheels."

A recent experience with a Ford car illustrates the need of the owner thoroughly understanding his braking system. This was a case of a new car where the owner had not yet become very familiar with the mechanism. He came to a very long and fairly steep hill. He released the clutch and applied the brake as he had been taught, and got about two-thirds of the way down the hill when the brake lining burned out and the brake no longer held the car. Then, because he forgot what he ought to do (or else did not know), the owner lost his head and thought he was going to smash, and of course did. The car ran into the ditch and upset, bent the front axle, broke the mud guards and top bows, and mixed things up generally, but fortunately no one was hurt.

This was all unnecessary, for on this particular car he had three other means of braking. He could have pushed the pedal which engages the low-speed gear and kept the car at low enough speed to negotiate the hill in safety. Or, he could have pushed the reverse pedal, which on this particular car would have acted as a very efficient brake. And, also, he might have applied the emergency brake, as on any other car.

As every car is equipped with two distinct sets of brakes, drivers should learn to use first one and then the other on long grades, and this may be helped out considerably by using the motor as a brake—that is, by cutting off the ignition and allowing the machine to push the engine under compression, and even more by engaging a lower gear before cutting off the ignition, so that there is a greater leverage obtained to retard the car. Likewise, long grades should be descended at a comparatively slow speed in cases where the brake is at all necessary, because the higher speed develops more heat and the brake lining is more likely to burn out.

Of course the brake lining has been improved so that it does not actually burn out very readily, but under extreme conditions it will become charred and lose its frictional qualities.

Perhaps one of the greatest causes of brake failure is oil. Now the oil which gets on the brakes usually works through the rear-axle housing from the differential gear. The owner may be a little too enthusiastic about lubrication and may put too much oil in the differential and it travels along the inside of the axle tube. The wheels are so placed on the axle that this oil can get out only by working over the wheel bearing and into the brake drum. It will often be noticed that the oil collects mostly on the right-hand brake. This is because the crown of the road, and perhaps the ditch alongside of the road which is used in passing other cars, tilts the car so that the right-hand wheel is lower than that on the left-hand side. Even where too much lubricant is not used, it seems that some cars have a tendency to leak oil from the right-hand wheel housing.

Usually this trouble may be overcome by taking a long, thin strip of hard felt of the proper thickness to fill the space between the axle shaft and the axle housing, and winding around the shaft in helical form, so that the action, when the shaft is turned, is to force the oil back toward the differential. Of course, if the felt is not wound in the right way it would have the opposite tendency and draw the oil out into the wheel bearing.

For this reason the felt should be wound, starting from the wheel end, in a direction opposite to the forward motion of the wheel, covering the axle for a distance of six or eight inches. The felt should be fastened to the shaft with shellac and bound in three or four places with cord.

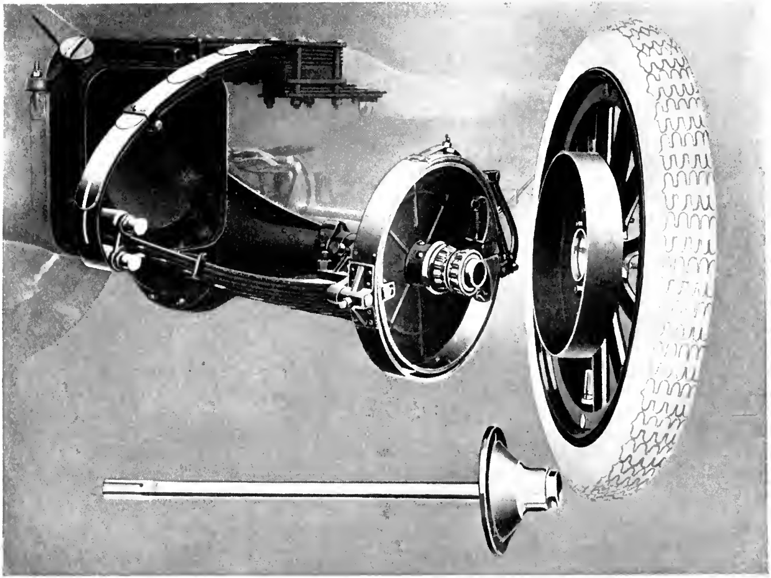
While oil on the brake bands is not desirable, oil on all of the bearing points of the brake mechanism is highly desirable. Some time, when driving in a city, take notice of the number of times the brake is applied. Then stop to think how each action is taking place in the brake mechanism. This ought to bring one to realize the necessity of lubricating the bearing parts. These need more frequent oiling because they are placed where they pick up more than the usual amount of dust and grit. If the lubrication of these parts is neglected they are likely to wear unduly and become so weakened that a sudden emergent strain would mean a break; and this might happen at a time when failure means death to the occupants of the car.

Brakes of modern design are so arranged that the bands clear the drum entirely when they are disengaged. This is done by means of springs and other devices placed around the drum at different points. These springs should be inspected occasionally to make sure that they have not become broken or otherwise fail in the performance of their functions.

Another cause of brake failure is due to the lining wearing thin and allowing the copper rivets, with which it is fastened to the band, to come in contact with the brake drum. This in time scores grooves in the drum and greatly reduces the braking effect. It is not economy, therefore, to wear the brake linings entirely through. When they become thin the linings should be inspected, and be replaced as soon as the rivets begin to show wear.

The usual practice is to have four brakes, one on each rear wheel operated by the service-brake pedal and one on each rear wheel operated by the emergency lever. The emergency brake is designed more for holding the car at standstill after it has been stopped, but may be used alternately with the service brake on long grades. The service brake should be kept in such condition that it will bring the car to a stop within a reasonable distance at any car speed, and it should be understood by the driver that the emergency brake is not intended to be used to help out the service brake which holds poorly when a quick stop is desired.

Many manufacturers term the second brake the hand brake, rather than the emergency brake,



REAR WHEEL AND BRAKE DRUM REMOVED, SHOWING EXTERNAL AND INTERNAL BRAKE BANDS AND MECHANISM

to discourage the idea that it is to be used to help out when an extra quick stop is desired. Too many owners go upon the assumption that one good brake is all that is necessary, and allow one to get into such condition as to be useless when the other fails unexpectedly, or when it is desirable to use the two sets alternately.

As to the adjustment of brakes, it is very important, in order to get the best braking effect—and to save wear on the tires as well—to have both brakes of a set give about the same friction. There are two places where adjustments may be made, one at each brake and one on the brake linkage, usually on each side, but possibly on the single rod connected to the pedal. By means of these two adjustments it is possible to have the bands clear the drums when the brakes are released and at the same time have each brake start to take hold at the same time and with equal force. The equalizing bar helps out in small variations, but cannot be expected to take care of the entire adjustment.

When one considers the multitude of accidents because the "brake gave way" and of the risk taken by others who fail to care for this important bit of mechanism, it would surely suggest to the careful man that he study the construction of the brake upon which he depends on a down grade and that he give it enough attention to know that it is in working order. If he does not value his own neck enough for that, he should at least have a care for those who share the danger.

CHAPTER XVII

WHY THE AUTO STEERS EASILY

Visions of disaster come to the automobile driver at the thought of running without the steering tie rod. One thinks of wheels trying to go in divergent directions and of ultimate destination in the ditch. As a matter of fact, it is possible to run along quite a while at moderate speed with only one wheel connected to the steering apparatus, and experiments have demonstrated that this can be done at quite a lively gait, on a speed track, whether straightaway or oval. There are several other peculiarities about the front wheels of an automobile which are not fully understood by automobile men, unless they have had technical training.

Most people think the front wheels of an automobile should be perfectly true in every way; that is that they should run parallel, but as a matter of fact they do not run parallel from any viewpoint. The front wheels actually toe in to a slight degree—that is, the distance between the front part of the wheels should be one-quarter to three-eighths of an inch smaller than the distance measured between the back parts. The tire manufacturer will tell one that the wheels must be in perfect alignment if full service is to be gotten out of the tires. This is true in a degree, but auto manufacturers understand that there must be a slight foregather.

Theoretically there would be a wear on the tires if they were at all out of true, but when it comes to the practical consideration of an automobile there are certain variations of this which are necessary to make the operation of the car safe and a matter of ease.

Of course there cannot be too great a difference in the alignment, but a very slight difference is necessary to enable the steering to be a matter of certainty. There will be, of course, an intangible amount of wear, but it does not cut any particular figure in the life of the tire and it gives a stability in the steering which cannot be neglected.

Perhaps it can best be illustrated by referring to two types of boats which are familiar to most persons. One is the scow with the square nose, which is very hard to steer either with or against the tide;

it is pushing flat against the water and there is no lateral pressure to keep it steady. The pointed-bow boat, the ordinary type, has a pressure upon each bow so that there is a constant resistance against any extraordinary pressure from either direction. This makes it necessary in steering to exert a certain pressure to turn the boat about. In actual practice it keeps the boat from wobbling. The same is true when applied to the front wheels. If they are perfectly aligned there will be no tendency to give one way more than another and very little pressure would tend to turn the wheels aside and make the car wobble. Experience teaches that this actually occurs.

At the automobile school, of course, there are many novices learning to steer a car, and they are taken out by experts. Where the wheels are actually aligned perfectly the wobbling effect, especially where the mechanism is a little worn, is very disconcerting to the student. Now, if the wheels toe in there is exactly the same pressure effect working from opposite directions. Each seeks to go slightly out of true and each offsets that tendency in the other. This naturally keeps the car steady and the wheels pass over slight obstructions without turning them in the slightest degree; only a rut or some large obstruction would cause them to turn and this would be the case under all circumstances.

In case there is wear due to neglected lubrication or otherwise, the wobbling tendency is especially noticeable. With the wheels toeing in slightly this is overcome, because pressure is exerted on the knuckle pins, keeping them firmly in place, even though there be considerable wear. The pressure being from both sides, it naturally takes up the play in both knuckles the same as with a chain when it is drawn tight.

Nor do the front wheels run in an absolutely vertical position, for they are set to undergather. This is done to save the tremendous strain upon the knuckles and make it possible to have these much lighter than would otherwise be the case. The fact of the undergather, of course, takes the strain off the steering knuckle pins. Were the wheels absolutely vertical they would set two or perhaps three inches outside the knuckle. The weight line being directly through the knuckle to the ground, there would be a leverage of two or three inches which would put a tremendous strain directly upon the knuckle; where the wheels are undergathered, the line of weight intersects both the knuckle and the tread contact, removing the item of leverage completely, and the wheel necessarily bears its full proportion of the load without undue strain upon the knuckle or pin.

Sometimes the pins are inclined fore and aft, that is, the bottom is farther forward than the top. This is to help in keeping the wheels pointed straight ahead by making the wheels into sort of a caster, so that they trail easily. The knuckles are directly over the center of the wheels and the line of weight would be directly downward, but the pins point forward. In this way, as engineers readily understand, the line of weight is moved forward and the weight is carried ahead of the contact point of the tire with the ground. Anyone who has ever ridden a bicycle understands the principle of this. In the old velocipedes where the wheel fork was vertical, it was very difficult to steer. Bicycle manufacturers discovered that by projecting the fork forward and transferring the weight line in advance of the wheel, they were able to make a machine which would naturally go straight ahead. The principle is exactly that of the caster. The roller trails along after the weight and so moves freely, even over obstructions, where it would be hard going if the roller were directly under the weight.

Now, as a matter of fact, wheels which are set in the manner described may run for a considerable distance without the tie rod, which fastens the knuckles together. It is usually understood that when the tie rod breaks there is bound to be a smash at high speed, and under most circumstances this might be true, but at moderate speeds it often happens that the car runs a considerable distance, steering perfectly, after the tie rod has been broken.

The author had an experience of this kind. He was going up Riverside Drive in New York City, toward the viaduct. After he had gone almost across the viaduct he was startled to see what looked like the tie rod protruding out in front of the car, although the car was moving along with no sign of trouble. The car was stopped and it was found that the bolt had jumped out of the knuckle on one side and that the tie rod had actually swung out in front, and not until then had it been discovered that there was any trouble.

Going back over the route across the viaduct and some distance beyond did not disclose the missing pin, but the conclusion was reached that it must have come out on the hill leading to the viaduct. Yet the wheels remained perfectly straight and the car steered properly, although there were no very sharp turns, and the car did not go to smash as it ought to have done in theory. It was the caster effect which saved the car from an accident. The trailing effect described kept the wheels running straight even after the tie rod was out of commission.

Some time later it was learned that the same thing actually had occurred in one of the big auto races. It so mystified the driver and his mechanician that they decided to experiment. They fixed up a car without a tie rod and started to speed up on the track. They attained quite a high speed without mishap and slowed down and drove to the shed as though the steering gear were regularly equipped.

However, it is not recommended that any automobile owner neglect to have his steering apparatus regularly inspected and to see that the pins are kept tight and that the wheels do not get too much out of alignment. The pin might drop out when going down a steep hill or when running at high speed, and tires do wear out when the wheels are too much out of alignment; but the instances cited show that sometimes strict theory and actual practice do not always meet.

CHAPTER XVIII

THE ELUSIVE "JUICE"

It takes good "juice" and lots of it to run a modern auto; not the kind that Uncle Sam has put a ban upon, for that ran the auto into the ditch oftener than most anything else; but something quite as hot and with at least an equal amount of "kick" in it—the electric "juice."

Probably this is the least understood element in running a car, if one may judge by the troubles reported. Large numbers of autoists have no idea of the functions of the batteries and wires and switches and other parts of the electrical equipment, and when anything goes wrong they are helpless.

In dealing with the electrical equipment of a machine the owner should understand that a complete circuit is necessary in order to have the current do its work; that is, starting with the battery as the source, a wire leads the current from the battery through the switch to the device to be operated, and then the current must be led back to the battery before it will do any work. It is not sufficient simply to lead the current to the device; if there is no way back to the battery it will not get even as far as the switch. It won't travel except on a round-trip ticket.

In looking for trouble electrically the first thing to inspect is the battery. See that it is charged—has current in it. That can be determined by using a voltmeter (for dry cells an ammeter) or a hydrometer. Then each successive terminal from the battery should be tested. For instance, there is a wire to the lighting switch. It is insulated and the first place to test after making sure that the battery is O. K. is at the switch. If there is no current there the wire may be broken or the terminal connections poor; but whatever the trouble may be, you have narrowed it down to one small stretch of wire.

The next step would be to test where the wire leaves the switch to go to the device to be operated. If the current gets to the switch and does not get out of it, it is apparent that the trouble is in the switch, or if it gets to the switch but not through the fuse, the fuse is at fault.

If the current leaves the fuse and does not get to the lamp which the switch controls, then we know that the trouble is in that wire somewhere; if it gets to the lamp but the lamp will not light, we know it is in the lamp; if we can trace it through the lamp, but it does not reach the battery, we know that it is the wire leading back to the battery which is at fault.

If the current is carried back through the frame of the car, as is very often the case, frequently the ground connections are poor or there is a break in the ground. Thus, we might attach a ground wire to a piece of iron on the dash, and if this is of wood that piece of iron might be insulated from the remainder of the metal work of the car and the ground connection would not be complete.

Recently the author came across some electrical troubles which were rather mysterious to the owners of the cars, but proved to be simple under systematic search. One man worked all of one Sunday morning, with the help of several sympathetic owner friends trying to find out where an extra wire on his switch should be connected. He could not get the engine started, the horn would not blow, the headlights would not light, the starting motor would not turn over, but the dash and tail lights, which were in series, did light.

A little experiment developed the fact that when the starting pedal was depressed the dash light grew very dim. This, of course, indicated that it was not possible to draw a very large amount of current from the battery, or that the battery was either in a discharged condition, or that the connections leading from it were poor. It was found that when the wire connected to the battery terminal was moved, the light would brighten up. This wire was disconnected and cleaned carefully to make sure that the contact was good. When it was assembled again no improvement was shown, so it was taken apart again and a careful inspection showed that one end of the taper on the inside of the terminal had a slight shoulder, which prevented the taper end of the wire from being drawn into place snugly. Therefore a very light contact was made and sufficient current could not pass to operate the starting motor. This shoulder was removed with a penknife and the engine started without difficulty. Several hours' time would have been saved if the owner had started to look for the trouble at the source of the current instead of puzzling over the end of a wire that was not intended to be connected to anything and had nothing to do with the trouble. It was simply an extra wire for use if some new device should be installed.

A week later this same man was unable to start his engine and again worked over it several hours before calling for help. This time the lights were all right, but the engine would not start. To determine the condition of the battery, he turned on a light and depressed the starter pedal as before, to see if the light would dim very much under the heavy load; as it did not, it was decided that the battery was all right this time.

The hood was open and it was observed that when the started pedal was depressed the fan did not revolve and therefore the engine was not being turned over, though one could hear the starting motor buzzing plainly. This showed that the overrunning clutch of the starting motor was slipping. As correcting this trouble was a shop job, they cranked the engine over by hand, but still it did not start.

To make sure that a spark was being delivered, the wire leading from the ignition coil to the high tension distributor was disconnected and given about $\frac{1}{16}$ inch gap. As soon as this was done it was plain to see that a spark was being delivered, and the engine started immediately also. Making a slight gap in the secondary circuit increases the intensity of the spark at the plug and often aids in starting a balky motor. This was an occasion when an outside spark gap was of value. After the engine was warmed up, it was started several times without difficulty.

Another fellow who was in trouble had a "sick" horn. It sounded like a man who has a cold clogging his vocal organs—that is, it gave a cracking or rattling sound instead of a musical note, if the sound of a horn can be called musical. This type of horn has a notched wheel which revolves and strikes against an iron pin riveted into a disc. The disc in this way is made to vibrate, giving the desired sound. An examination showed that the pin had become loose and rattled. It was explained to the owner what the trouble was and he was told that the pin was of hardened steel and as it was rather difficult to rivet it, it might loosen up again. He replied that he would not worry about that, because now that he knew what the trouble was he could easily get it fixed again or replace it if necessary.

Another fellow had a horn which would not play because it had become grounded and blown the fuse. The ground was removed, but as no fuse could be obtained, a single strand of very fine wire from an ignition cable was substituted in place of the fuse. This wire was small enough to burn up before other short circuits could do damage to battery or wiring.

Still another fellow had his car laid up for a week while he tried to find out what was the matter with it. He had sent magneto and coil to the factory for repairs and when they were returned to him a new type of coil was provided. He wired it up the best he knew how, but the engine would not start. Checking the wires over very carefully, they seemed to be placed properly, but a spark could not be obtained. Going to the source of the current, a test of the dry cells with an ammeter showed that they were dead. The fellow had lost a week's use of the car because, having decided that the trouble was at the magneto or coil, he did not look anywhere else. He should have started at the battery to trace the current.

Another case which came under notice was where one of the headlights failed to light. A test showed that the current came to the lamp. To make sure the lamp was not at fault the one from the opposite side was substituted, but it would not light. The lamp was grounded by an extra length of wire and it worked all right. Then it was found that the ground wire, which was located back of the reflector inside the lamp, had become loose.

Most of these troubles point to the fact that a complete circuit is necessary to have an electrical current do its work. Therefore, when trouble occurs, the source of the current should be examined first and then the current should be traced through its entire path leading from and returning to the battery.

It might be a good idea for the owner on winter evenings to get out the wiring diagram of his car and trace the current from the battery through each light, through the ignition system, through the horn, and through every other electrical device used on the car, including the generator and starting motor.

Also it might be good practice for the owner to carry his wiring diagram with him when touring, so that the garage man, if there be trouble, may be helped to quickly locate it. But if the winter evenings be spent wisely in studying the electrical equipment, or even the entire car, or perhaps invested in a course of instruction at a good school, the owner might be independent of the garage man for the most part and besides have the satisfaction of knowing that when anything does go wrong he can find it and in most cases fix the trouble. The release from worry ought to be worth the time spent in learning how.

CHAPTER XIX

PUTTING THE KICK IN THE SPARK

MOTORS are a good deal like men. Very many of them, when everything is wide open and they are hitting it up at top speed, have excellent performance, but spit and sputter and knock a bit when compelled to travel at a lesser pace.

This is not moralizing, but the natural deduction from the complaints which are constantly received. A great many drivers want to know why it is they cannot throttle down the engine; they say it will pull well at medium or high speed, but skips at the lower speeds.

Where magneto ignition is used, this often may be overcome by adjusting the interrupter points for a little wider gap. That makes the interrupter points open a little earlier and causes the spark to occur when the magneto armature is in a more favorable position, and the spark therefore has more kick in it.

The interrupter points usually are adjusted for normal running speed, or a little higher than medium speed. Increasing the number of revolutions per minute of the armature causes a distortion of the magnetic field, which tends to follow the armature. This distortion is not so great at lower speeds. To overcome the distortion, which in effect twists the field around so that the points do not open at the period of greatest current potency, we must change the time when the points open and cause the spark; therefore, to get the best spark it is necessary to have the points open earlier. Widening the gap between the points accomplishes this.

If the engine misses at high speed, close the points a little to make the opening come later and when in better armature position, the action being just the reverse of the foregoing paragraph.

Widening the gap of the spark plug also will help to overcome skipping at low speeds. At low speeds a full charge of gas is not drawn in and compression is low and temperature low in consequence; the mixture is not so near the self-ignition point when the spark occurs as it is at higher speeds. Therefore a better spark is needed to ignite it. By widening the gap in the plugs the secondary current is held back until it acquires high enough potentiality to jump the greater gap; so that when it does occur an exceptionally powerful spark is obtained.

This may be demonstrated with the use of a vibrating coil. Set one of the cylinders on top of compression ready to ignite. Turn on the current and while the vibrator will buzz the spark inside the cylinder is not strong enough to ignite the charge. Now detach the spark-plug wire and hold it close to the outer plug terminal and turn on the current. The extra gap will increase the strength of the spark in that cylinder and it will ignite the charge, starting the engine. This has led to the use in some cases, of outside spark gap attachments.

Widening the gap and getting a longer spark is not what ignites the charge. It is simply that the greater gap causes the current to build up to a higher pressure, or voltage, before it will jump the gap, so that when it does occur it is of greater intensity.

There are several other things about sparking not generally understood by the novice. The general opinion is that the greater insulating surface of a plug there is inside the cylinder the less likelihood there is of short circuiting and consequently the more certain will be the spark occurrence. This is only partly true; it is true so far as short-circuiting is concerned; but where the surface is too great and soot or carbon is deposited upon the insulator surface, the carbon acts as a condenser and absorbs the secondary current. The effect is that it will not build up a sufficiently high voltage to jump the gap. Very heavy insulation on the secondary wires absorbs current in the same way.

The fact that the spark jumps across the points of the plug when it is in the open air does not necessarily mean that it jumps when the points are under compression in running conditions. A current which will cause a spark to jump a half-inch gap in the open air, will cause it to jump a gap of only $\frac{1}{32}$ inch under normal running compression. Failure to appreciate this often results in a man thinking his ignition is all right when there may be a crack in the insulation so small that it scarcely can be seen with the naked eye when cleaning the plug, or there may be a porous spot in the porcelain, either of which would leak current under compression. Many manufacturers test the porcelains to see if they leak, using a spark gap of $\frac{3}{4}$ inch under a very high voltage.

If there is carbon on the porcelain, the current very often will travel through this under high compression, because there is less resistance offered by the carbon than by the spark gap. It short-circuits the plug and there is no ignition. Yet, when this same plug is removed and tested in the open air, there will be a good spark; the resistance of the gap in the open air would be less than the resistance offered by a path through the carbon coating. If on testing a plug in this way there seems to be a good spark, yet the cylinder will not fire, clean the plug thoroughly and try it out in the cylinder. If it still does not fire, try a plug which you know is all right and see if it fires. If it does, you may know that the old plug leaks current somehow and probably needs a new porcelain.

It is a common error with motorists when cleaning a spark plug to polish up the points and call it a job. What really is required is to remove all of the carbon, which is a fair conductor of electricity, from the porcelain or mica and get these back into the insulator class again.

The conditions which allow the adjustment of the interrupter points in magneto ignition to accommodate certain speeds, do not arise when battery ignition is used. Battery interrupter points are usually adjusted for an opening of $\frac{1}{64}$ inch and the gap at the spark-plug points must be greater usually than when magneto ignition is used, because the spark given by battery systems is naturally of less volume than that given by the magneto. Therefore the gap must be greater to intensify the current as before described.

The interrupter points sometimes become coated with an insulating glaze, composed of oxides and dirt hammered by the action of the movable interrupter point, or hammer. The points will have the appearance of being all right; there will be no pits or points; nevertheless there may be enough insulating material there to keep the current from flowing and no spark will occur in consequence. The points may be cleaned by inserting a very thin file between the points when they are open and then allowing them to close on the file, being held together with no more pressure than the spring exerts, and working the file back and forth until the glaze is removed. It is necessary to have a flat surface, so that care in using the file is needed, and, as platinum is more valuable than gold at present, it will be apparent that as little filing as possible should be done.

The condenser is another point of possible trouble. The condenser increases the volume of the spark about twenty-five times. We often find that a very weak spark may be caused by a partial breaking down of the condenser, or occasionally to the fact that it is disconnected at the terminal. Condensers are usually hidden away so that the novice cannot locate troubles of this nature, but an excessive sparking at the interrupter or vibrator points, with a very weak spark at the plug points, indicates that the condenser is not working properly. When this sparking occurs have an expert examine the condenser for trouble.

CHAPTER XX

WHAT'S THE TROUBLE WITH MY BATTERY?

WITH the coming of the shorter days in the year a frequent complaint to garage man and battery or electric-system expert has to do with the battery, though in nine times out of ten the man with the kick does not know that it is the battery. He will talk about the lights failing every once in a while, or the horn refusing to honk on demand. But in the majority of cases it is the battery which is at fault.

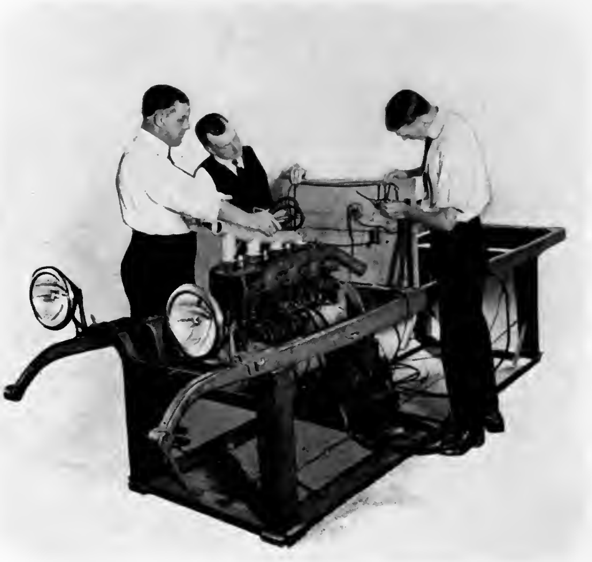
It is more difficult to keep the battery charged at that time of the year than it is in the summer. The reason is that the sun sets earlier, and just as our electric light and gas bills mount at home, because we light the lamps earlier, so it is with the auto. The driver who obeys the law uses more current.

One complaint came from an owner who was experiencing trouble with his electric plant. The lights would not work right when he was running.

Starting out there was light, but after running a short time there was trouble. The lamps were fitted with dimmers and these would not work at all times; sometimes one would light and the other fail. He went to the garage repair man and then the dimmers would not work at all. He went to an expert electrician, who looked over the battery and declared it to be all right, but on the ground that he was a battery expert and not a wiring expert he could not say why the lights would not shine and the owner had visions of stern policemen and the possibility of having to face a traffic judge, and he sought advice elsewhere.

In the meantime his troubles multiplied. The horn—electric—refused to honk at times and got so that it worked only after the car had been running half an hour or so. This was the case the writer was asked to diagnose.

While trying to determine the cause, questions asked developed that the owner was employed during most of the day and only ran his car nights, except that he was making long trips on Saturday and Sunday, and ran quite late into the night both days. During the week nights his trips were short, with numerous stops. This caused frequent use of the self-starter. He found



THEN HE WENT TO SCHOOL TO LEARN SOME MORE ABOUT HIS CAR

it took longer to start the car, a natural result of the cooler weather.

These facts suggested that the battery was being starved; that is, that it was not getting enough charge to keep it at its best. There seemed to be no trouble with the wiring and the owner was told he had better have the battery charged and see if his troubles did not end. They did. Then he went to school to learn some more about his car.

His trouble was that he did most of his running at night and as he carefully observed the speed laws, consequently the generator did not generate very much extra current and the battery was being recharged at a very low rate and being discharged at a rather high rate. In other words, he was chopping off both ends—burning both ends of his candle. He was using an excessive amount of current and generating less than usual because of running at night, starting often, and running slow to observe the speed laws. Up to a certain point, the amount of current which goes into the battery is increased in proportion to the speed of the car.

Generators are constructed so that they will deliver a normal charge to the battery for normal running; they must not be constructed so they will send out excessive current, or they will overcharge the battery, and that is harmful. The sun sets much earlier in winter and the cool weather makes it necessary to use the starter more. In warm weather one little kick will start the car off; in cold weather it takes often from half a minute to a minute.

Most engines now are equipped with carburetor check and priming devices to facilitate starting when the engine is cold, but even with these more current is consumed in starting the engine than when it is warm.

Then, too, the storage battery drops off in efficiency as the temperature is lowered and will not deliver so much current on a full charge as at a higher temperature. This comes at a time when there is a greater call on the battery, and where a battery fails under such circumstances, it is wise to get an occasional charge to help out the generator.

It is becoming the practice to take all current for lights, ignition, and other purposes direct from the battery, using a generator to recharge it. Inside of a year at the most the bottom of the battery will become filled with a sediment from the plates. This causes an internal short circuit and the battery will discharge itself inside instead of outside. At least once a year a battery should be taken apart and the sediment be cleaned out.

Some generators are constructed so that they can be adjusted to deliver more current on demand; that is, there is one adjustment for summer and one for winter running. Wherever it is possible to do this it should be done. Otherwise, when a battery loses voltage, it can be taken off the car and be charged. It need not be necessary to leave it for a twenty-hour charging period; if taken soon enough it can be charged in six to ten hours, or, when the car is laid up over night. Two nights would be enough at any rate.

As a matter of fact, in self-starter practice, everything is done to the storage battery that formerly was included in the list of battery "don'ts." On account of the exceptional demands of self-starters, batteries have been improved so that they stand this to some extent; but the improvement has not kept pace with the extra demand put upon the battery.

Some of the old "don'ts" are:

You should not charge the battery at a high rate when completely discharged.

It should not be charged at a high rate when almost fully charged.

It should not be overcharged too often; occasional overcharge is good, but not too often.

It should not be discharged at a very high rate.

Most self-starters are of the two-unit type; they have a generator for recharging the battery and a motor for cranking the engine. In other self-starters the two units are combined; the same instrument, when current is fed to it from the battery, kicks off the motor and when driven by the engine acts as a generator.

When self-starters were first introduced they had all sorts of devices to offset the high-current demand and regulators and cutouts to comply with the battery-makers' directions in recharging. These devices were complicated and could not be depended upon, and consequently were discontinued, and it was put up to the battery to stand the abnormal conditions. The battery makers have been trying to offset this and to a certain extent have succeeded, but as it is directly against former practice—for every one of the "don'ts" is disregarded in self-starter systems—the makers have not been able to rectify conditions entirely.

On account of these conditions the life of a storage battery may be considered to be about one and a half years, and if it lasts as long as that it is considered to have done its work and to be entitled to be retired.

But if your battery seems to fail with the coming of short and cool days, do not discard it until you have tried having it recharged, for possibly you have simply been overworking it and not feeding it enough current to keep it in condition.

CHAPTER XXI

WHY GEARS STRIP

Some of the most unnecessary and expensive repairs to an automobile are those connected with its transmission. It is not only exasperating, but unnecessary to be told that the gears of your car are stripped, or that the teeth are broken so that smooth running is impossible, if indeed the car can be run at all.

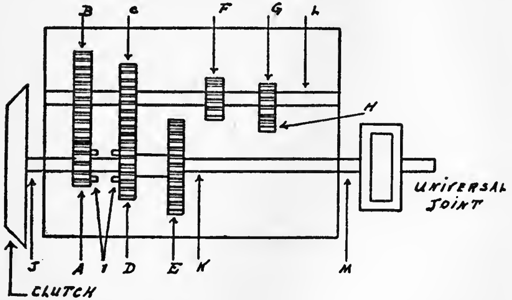
It is not in the permanent mesh gears, where shaft motion is turned into axle motion, that the trouble comes. Properly set and packed the rear axle gears never should make trouble. But it is in the shifting gears of the transmission, where gears come to mesh at varying rates of speed, and with the number of revolutions, load, and several other things to complicate the situation, that there is wear and tear—largely tear.

If an automobile could run at an unvarying rate of speed, if there were no hills which require the translation of speed into power, or if the engine controls alone could give sufficient speed regulation to cover the emergencies constantly arising, the transmission might be simplified into a mere coupling and reverse. But simplify as you will, there must be provision for varying speeds and these must be attained while the car is in motion, and this means the meshing together of finely built gears revolving so fast the teeth cannot be seen.

It is no novelty to hear a grinding or clashing within the car when a careless chauffeur starts, or when he changes from one speed to another. If the owner knew what was going on inside to make all that noise, a new chauffeur would have a job quickly and there would be laid down starting, speeding, slowing down, and stopping rules as stringent as those of the traffic policeman.

The illustration gives the mechanism of a simple transmission gear case. The engine shaft J has on the end a gear wheel A, and on the face of the gear are four engaging teeth I. The end of the shaft J is hollow and in this revolves one end of the transmission shaft K, which is square. On it are two gear wheels of varying size, D and E, one having, say, thirty teeth and the other forty. The smaller is yoked to the larger and both slide along the square shaft when moved by a lever.

The gear D has on its face engaging teeth I, corresponding to those on the engine shaft gear A, and when the two are engaged the transmission shaft revolves at the same speed as the engine



shaft, giving the highest speed of which the car is capable.

To provide for varying speeds, another shaft is suspended in the transmission case, on which are other gears. If gear A has twenty teeth, B will have, say, forty. This reduces the motion of the gear shaft to one-half that of the engine shaft. Farther along the gear shaft, gear F, with twenty teeth, engages gear E with forty, further reducing the speed, so that the transmission shaft revolves one-fourth as fast as the engine shaft, making the low gear, or slowest speed.

When the car is standing, of course, gears E and F are not engaged, but the engine is running in neutral—that is, no gear on the transmission shaft is engaged, gear E being shifted just far enough to miss gear F. To start, it is customary to disconnect the engine and move the lever so that gears E and F engage. If the speed of the engine shaft be 600 r.p.m. that of gear F would be 300 r.p.m., or 6000 teeth pass a given point per minute (300 x 20)—something of a buzz-saw motion. Into this revolving mass of teeth the forty teeth of gear E, which is at rest, must penetrate and mesh. It does not require much of a mechanic to see that the meshing must be quite perfect or there would be a clash and grind that does no good to delicate machinery. So it is good practice to allow enough time after the clutch is released for the moving shaft to come to rest.

Once the car is under way and it is desired to increase the speed, the lever is shoved forward, moving the transmission gears forward until gear D engages gear C. These are the same size and have, say, thirty teeth each. But they are not moving at the same speed. Gear C, revolving at 300 r.p.m. puts 9000 teeth per minute past the engaging point, while gear D, moving at 150 r.p.m. puts just 4500 around per minute. The difference of 4500 represents the possibilities of clashing and breaking or stripping the gear. The wise chauffeur just at the instant of shifting the gear, would throttle down his engine one-half and bring the number of revolutions of the gear shaft to approximately that of the transmission shaft, which is kept in motion by the momentum of the car. He also will hesitate in the shift—that is, stop for an instant in neutral before completing the shift, to allow for adjustment. It is possible in this way to lessen the difference in teeth speed. If it were possible to make both gears revolve at exactly the same speed the shift would be noiseless and frictionless. This is practically impossible in actual running, though in theory it can be done. But they may be brought near enough to minimize the clash.

In shifting to high speed from medium, the engine should be throttled more closely and the shift lever should hesitate again, if one would avoid the thump and jerk commonly felt when the high gear is thrown in. The engaging teeth of gears A and D will stand a sledge-hammer blow, but "constant tapping wears away the hardest rock," you know, and the best gears made wear and break. Besides there is the jar to engine and car to consider. Constant jerking and jumping rack the mechanism, chassis, and body and shorten the life of each, so that economy, if not comfort, would seem to dictate care by the driver.

In reversing the operation—that is, going from high to medium and medium to low, one needs to reverse the directions given for increasing speed. Still assuming the engine shaft to be running 600 r p.m., gear D would have that speed and would throw 18,000 teeth per minute (600 x 30), while gear C, as before, would be going at 9000 teeth per minute (300 x 30). It would therefore be wise to stop in neutral, engaging the clutch to speed the engine up, and then release the clutch before engaging the lower gear, bringing gear C to somewhere near the speed of gear D. In practice it is approximated by not releasing the clutch fully when changing to lower gear, thus preventing the clutch from reducing its speed. To accomplish this speedily, however, the car speed must be reduced considerably before attempting to make the shift.

Going on to lowest speed, gear E would now be moving at 300 r.p.m. and gear F at 300 r.p.m., but gear E's forty teeth move at 12,000 per minute and gear F's twenty teeth at 6000 p.m., to correct which one should speed up the engine, or check the car, in the same manner as just described.

In reversing, to back the car, the gear operation intensifies the problem. In the illustration, gear G operates gear H constantly, the action being to reverse the motion in the latter, and when gear E engages gear H to reverse the motion of the transmission shaft and thus back the car. In addition to the difference in speed and variance of teeth revolutions, there is added the contrary direction of the two gears which are to engage. To throw back on reverse even at moderate speed menaces the gears and shakes things up uncomfortably. Fortunately it is almost invariably necessary to fully stop the car before reversing, and necessity of caution in backing prompts very low speed throughout the operation.

Care in operating the gears will add much to the life of the car and to the pleasure of the owner, and chauffeurs should be instructed in the proper handling of the speed and reverse levers. It racks one's nerves when riding to hear gears clash and grind on a passing car, and many of the taxis seem to have this trouble.

The chauffeurs run the cars on a slap-dash method and disregard of the gears is a part of it all, but it costs the owner much in upkeep and renewals.

CHAPTER XXII

THE GEAR-SHIFTING BUGABOO

PROBABLY the chief bugaboo of the new owner is gear shifting. This is evident from the fact that the average motor-driving novice will leave the gear in high when the car is slowed down practically to a standstill, and make the engine labor in order to pick up speed again, rather than run the risk of making a noisy shift. He has learned from his brief experience that, in addition to the noise he creates, he does not mesh the gears anyway, and has to start off from a standstill. Consequently he does not shift gears, but makes the engine start on high-speed gear.

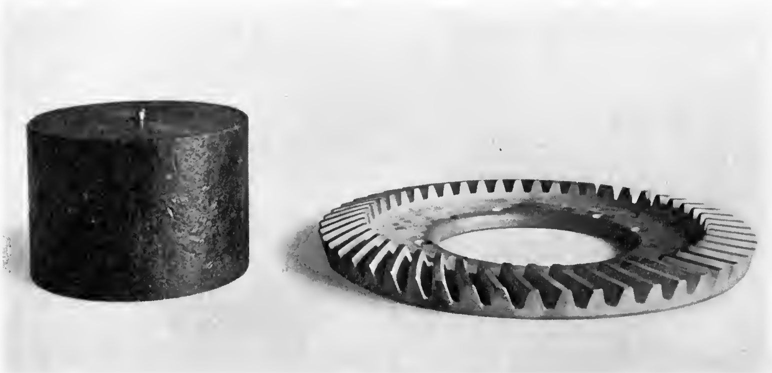
This, no doubt, is the cause in a large measure of the great popularity of six-, eight-, and twelve-cylinder engines, since with motors of this type the gear shift is not so necessary. There is a greater range of speed; a greater flexibility and power may be delivered at lower speed. Even the manufacturers of four-cylinder engines have designed their motors for higher speed with greater gear reduction, which makes it easier for the engine to pick up the load from the very lowest speed, consequently making the car more popular with the prospective owner.

Inventors are continually at work trying to devise simple methods of bringing about an adjustment of load to speed without actually sliding the gears into mesh, and one very popular type of car is arranged so that no sliding of gears is necessary, and another one or two leave out the gears entirely.

However, the three-speed sliding-gear transmission seems to be the most satisfactory, considered from all standpoints, including cost of manufacture, ease of repair and care required, consequently the owner should learn at once how to manipulate the gear lever with a minimum of noise, which is largely a matter of practice.

If a man should get into a strange car he could hardly be expected to shift the gears noiselessly under all conditions; but a man who owns a car and drives it should very quickly learn the peculiarities of that particular car and be able to make the required gear shifts with ease and confidence.

Shifting gears at the proper time saves racking



CYLINDER OF STEEL, AND THE GEAR WHEEL WHICH WAS HAMMERED FROM IT

the entire mechanism of the car. It usually is not very difficult in the average car to shift to a higher gear, although some car owners manage to stir up considerable noise in doing this. One of the sources of trouble in this respect is a dragging clutch. But most cars now are equipped with a clutch brake, and by depressing the pedal far enough this brake is brought into play and overcomes the tendency to drag.

Usually the best results can be obtained in shifting from first to second gear by speeding the car up a very little on first, shifting out of first and hesitating an instant in neutral and then shifting into second. Unless the clutch-brake action is harsh the clutch pedal should be depressed all the way in making this shift. The procedure is the same in shifting from second to third. Care should be exercised, however, not to speed the car up too much before shifting, and the throttle should be in closed position and the accelerator pedal released during the time of the shift.

Changing from high to a lower gear is where the most of the trouble is experienced and this is usually due to the fact that the car is being driven at perhaps twenty-five to thirty miles an hour and the driver for some reason or other thinks he is going to have use for the second speed. Immediately he proceeds to shift; the result is audible for half a mile. Usually no difficulty would be experienced in shifting to a lower gear if the car speed is diminished sufficiently. As a general rule, when shifting to a lower gear the speed of the car should be a little less than when shifting to a higher, between the same relative gears.

In ordinary driving the gear need not be shifted to first speed except when the car is brought to a standstill and on a level road the second-speed gear need not be employed until a speed as low as five to ten miles an hour is reached. The gear should be shifted when the car speed has been decreased to this extent, and the driver should guard against shifting before slowing down simply because his judgment tells him he is going to have to use a lower gear, if he desires to make a silent shift. There is a tendency to anticipate the necessity and then to do it immediately and before it is required; the consequence is noise.

When climbing steep hills it is desirable to make the shift at a little higher car speed than on the level, otherwise the car may lose so much momentum during the operation that the engine will be unable to pick up the load and will stall. This is a rather difficult situation which needs special handling.

In a great many cases a silent shift may be made on a hill by leaving the throttle slightly open so that the engine speed will increase when the clutch is released and make a very quick shift with the clutch but partly released.

After the driver becomes a little experienced he may shift from third to second without sound at practically any car speed that the engine is able to deliver on second gear. This may even be found of value when climbing steep hills and in anticipating necessary shifts. To make this shift at high speed, release the clutch, shift gear lever to neutral notch, engage clutch, and accelerate engine speed to a point which experience tells you is the correct engine speed for second gear at that car speed, disengage clutch and shift into second. This is a matter for experiment and experience.

In starting the car grinding of the gears occurs because the owner has not patience to wait the five seconds that may be necessary for the clutch to stop spinning before meshing the gears.

Another source of annoyance which often leads up to a noisy gear change, comes from the fact that occasionally it is not possible to bring the first-speed gears into mesh when about to start the car. This is due to the fact that the gear teeth line up so that the gears cannot be slid into mesh.

This may be overcome by leaving the lever in neutral, engaging the clutch so that one gear will spin, and then disengage the clutch again before shifting the lever. It may need one or two repetitions of this before accomplishing the desired result, but a little patience will save strain on the gear and a minimum of noise in shifting.

A noiseless shift cannot be made from first to reverse or reverse to first unless the car is at a standstill.

CHAPTER XXIII

THE MUFFLER

MUCH despised, detested by many automobile operators and neglected by almost every chauffeur, and even "cut out" altogether when the traffic policeman is not around, the muffler plainly ought not to be so treated. It is deserving of careful consideration every once in a while, if the owner cares much for efficiency and economy in operation.

The muffler is located under the car, and being out of sight is usually out of mind. It is therefore often neglected or misused. And yet it ought not to be. The muffler is placed on the end of the exhaust pipe, and its sole purpose is to silence the exhaust of the engine so that the driver of an automobile while taking pleasure himself does not wholly deprive others of it.

Let us consider the use of the muffler. The exhaust valve opens while the burned gas is still under a pressure of from twenty-five to thirty pounds per square inch. If this were exhausted directly into the air the resulting noise would stifle conversation in the car, annoy everybody along the street, and quickly get the driver into trouble with the police. The muffler prevents all this. It provides a chamber in which these exhaust gases may expand and cool somewhat and at the same time breaks up the pressure by allowing it to leak out slowly through a number of very small holes, instead of letting it loose in one "big noise."

In the early history of the automobile, mufflers were not used and everybody for blocks around knew when an auto was coming. As the automobiles increased in number this became a nuisance and was stopped by law. Then they sought —indeed had been seeking—a means of stifling the sound. In the early muffler there was trouble because the gas would back up in the cylinder and decrease the power of the motor. It was thought there was no way to decrease the sound without decreasing the power; therefore the manufacturers devised a valve to "cut out" the muffler on the car whenever extra power was desired.

Sometimes the back pressure was so great as to interfere when driving through heavy roads or up hills. The "cut-out" let the gas exhaust directly into the air instead of going through the muffler.

At the present time nearly every city has a law prohibiting the use of "cut-outs."

As a matter of fact those well posted on automobile engines understand to-day that the "cut-out" is absolutely unnecessary on a modern car if the muffler is kept in proper condition. Muffler manufacturers have been able to produce a design with which there is no back pressure at all. For this reason manufacturers discourage the use of the "cut-out" on their cars and some of them will no longer install one except as an "extra."

The average driver, however, does not know that his muffler needs as careful attention as any other part of the mechanism and so he neglects it. In these days of noiseless cars it requires a great number of very small holes inside the muffler. These become clogged with soot or carbon from the exhaust. The deposit collects very rapidly, especially when the grade of oil used is poor or too much oil is used. It also results when the carburetor is adjusted to give too rich a mixture.

When these small openings become clogged, the exhaust gases cannot escape readily and naturally the cylinder of the engine is not cleaned at the exhaust stroke. Result: It is impossible to bring in a full cylinder of new gas on the next intake stroke. There is not a full charge to explode and this means a loss of power to the engine.

Cases are known where the throttle was opened wide without any increase in power. Trying to find out what the matter was the driver opened the "cut-out" and this caused the machine to accelerate very rapidly.

In other cases when the engine was cranked, there would be a few explosions, a sputter and a stop, and the reason was that the muffler was so clogged that it was impossible to exhaust the gas from these few explosions, the cylinder remained full of burned gas, and, of course, could not take in a further supply. These, of course, are extreme cases, but the writer had this experience not long ago:

He was riding in a car that could hardly make headway against a strong wind blowing. This meant frequent use of the second-speed gear, which in itself causes an undue use of gasoline. He found on experimenting that the muffler "cut-out" pedal could be used in place of the accelerator pedal; that is, when the muffler "cut-out" was open the engine had considerable more power and immediately speeded up. In fact, he kept the "cut-out" open most of the way home and had no more trouble in bucking the headwind. The experience led to the discovery that the muffler was almost totally clogged with carbon.

Of course, where the engine is stopped or there is a decided decrease in power, the owner will hunt for the trouble, and find it, perhaps, in the muffler. He might not notice less serious cases where, while the muffler is somewhat clogged, it does not decrease the power strikingly; but even in these less serious cases it will often be found that the power of the motor may be materially increased by having the muffler cleaned. Yet it is seldom done, even when the car is supposed to be overhauled completely. Many drivers seem to think the muffler can take care of itself. In looking over the inspection card of a well-known make of car it was found that no provision was made for even looking at the muffler. The service-station inspection orders contain no mention of the muffler.

There is still another cause of the clogging of the muffler with carbon, and that is the practice of putting kerosene in the cylinders to clean them. The kerosene cleans the carbon from the cylinder walls and that is what makes the trouble, for it is exhausted right into the muffler. Some drivers understand this and when using kerosene for this purpose open the muffler "cut-out"; this allows the discharge of the greater part of the carbon into the air, but even then some of it finds its way into the muffler and in time makes trouble.

A muffler of modern design, if kept clean, needs no "cut-out" arrangement, but if it becomes clogged it is necessary to use a "cut-out" when the full power of the engine is needed. The consequence may be a trip to the police station and then to the court and then a fine to be paid. It is evident, therefore, that if one wishes to get power out of his car on an economical basis and wishes to escape fines, he should look after his muffler.

Since instruction books, and even service-station inspection charts do not say much about the muffler, and since it is evident that it has an important part in the operation of the car, where the owner does not find sufficient information concerning it from the instruction books furnished him, he would better ask the agency to furnish him a special muffler pamphlet, which will show its construction and care.

CHAPTER XXIV

YOUR BEARINGS

EVER stop to count up how many bearings there are about your car? If you haven't, you are likely to lose your bearings while you hunt for the several hundred bearing points of the modern automobile.

A bearing is a support for a moving member, so designed as to minimize friction and receive wear, and to permit of fine adjustment.

There are many types of bearings, some in which the metals are selected with the idea of obtaining strength rather than non-friction qualities; others have strong metal shells lined with a comparatively soft non-friction metal. In these bearings moving members slide over each other.

In addition to this we have the so-called anti-friction bearings, in which balls, or straight, taper, or helical rollers are used, giving a rolling rather than a sliding contact.

On the engine alone there are 102 bearings.

This is figured on the average six-cylinder motor; some of them have more than double the number. There are, for instance, the following:

Six cylinders, 6 wrist-pin bearings, 6 crank-pin bearings, 4 main, 3 cam shaft, 12 cam, 12 push rod, 12 valve stem, 2 fan, 2 water pump, 8 ignition, 6 spark control, 6 carburetor control, 6 carburetor, 3 oil pump, 4 self-starter, and 4 self-starter linkage bearings; total, 102.

The first named, cylinder and piston, not generally termed bearings, are usually of cast iron, which gives comparatively long wear and in which the friction is not great if well lubricated. When wear does occur at this point it is necessary to rebore and have larger pistons fitted.

The wrist-pin bearings usually are in the form of a bronze shell, called a bushing, surrounding the wrist pin; when wear occurs it is necessary to drive out the bushing and replace with a new one which fits.

The crank-pin bearings are usually in halves, the metal babbitt or bronze, surrounded by a steel strap or casing. When wear occurs, the adjustment is made by taking out thin sheets of metal, called shims, which allow the halves to be brought closer together. The main crank-shaft bearings are of the same type.

The cam-shaft bearings are usually in bushing form, which must be replaced with new ones when they become worn. The cam-follower bearings may be just flat plates resting directly upon the cam, or rollers running on a pin in the valve push rod. Wear in these parts would usually be compensated for by adjusting screws on the valve push rods.

The push-rod guides are sometimes made of cast iron or other metal, with babbitt or bronze shell in bushing form, and would require replacement when worn.

The oil-pump bearings consist of a plunger working in a small cylinder, with one end bearing against a cam, or a pair of gears driven from the cam shaft. These bearings, being perfectly lubricated, seldom or never require adjustment.

All of the bearings considered so far are cared for by the lubricating system of the engine, which starts when the engine starts to run, and as long as oil is kept in the engine they are quite certain to be taken care of, barring accidental stoppage of the oil lead.

The fan usually runs on ball bearings which are lubricated with a squirt can; being usually of the cup and cone type, they are adjusted by tightening the cone. The water-pump bearings are lubricated by compression grease cups; when the bearings become badly worn it is necessary to drive out the bushings and replace them; generally the shaft also will need replacing. When this shaft becomes worn out of round, no amount of tightening of the stuffing box will prevent water from leaking out.

The valve-stem guides are sometimes bushings, but more usually are holes bored through the cylinder casting. In the former case, when wear occurs the bushing may be driven out and a new one, with new valve, installed; in the latter case, the holes must be reamed true and larger, and valves with larger stems be inserted.

In the ignition system ball bearings usually are employed, with or without means of adjustment. These are lubricated with an oil can or packed in grease. There is one bearing of the ignition system which is unique in that some manufacturers advise keeping it free of lubricating substance of any kind. This is the rocker arm of the interrupter on certain makes of magnetos. Other forms of interrupters are so constructed that lubrication is advisable.

The carburetor air-valve bearing operates better if not lubricated, but does wear and need replacing at times. The throttle bearings may be lubricated and would certainly wear longer if this were done. When they do wear air is admitted which is noticeable at low engine speed, causing skipping and irregular running. Then the holes in the casting must be enlarged and larger shaft inserted.

The throttle and spark-control linkage have a number of bearings, which may be of the steel ball and socket type, or a wire bent to fit in an eye. These pins should be frequently lubricated with a squirt can. Usually they are not adjustable, so that parts must be replaced when they become badly worn.

The self-starter motor and generator are usually equipped with ball bearings and are lubricated with a squirt can. Both the motor and generator have a copper commutator on which carbon brushes bear. These are not bearings, strictly speaking, but they do require a very slight trace of oil if the brushes have not been soaked in oil. The commutator becomes worn occasionally and must be smoothed up with fine sand paper, or, if badly worn, must be removed and trued in a lathe.

The other principal bearings throughout the car are usually of ball or roller type, which may or may not be adjustable. Usually the directions for the care and replacement are given in the manufacturer's instruction book.

In the steering gear there is a plain bronze bearing or bushing in which the shaft is set out of center, so that when wear occurs by twisting the bushing, the sector of the steering gear may be thrown deeper into mesh with the worm and take up the play.

In the transmission gear, in which all other bearings are of the ball or roller type, there will be found often a plain bearing on the forward end of the square or fluted shaft called the pilot-shaft bearing. This is one weak point in many otherwise satisfactory transmissions. When this bearing wears, the operation becomes noisy and the gears are difficult to shift. The transmission must be disassembled, the bushing withdrawn and a new one pressed in.

The steering-gear linkage bearings are usually of the ball and socket type, self-adjusting by means of springs. Steering knuckle bearings are usually bushings which may be driven out and replaced when wear occurs. It usually is necessary to replace the pins at the same time.

The universal joints of the propeller shaft become very noisy when the bearings are worn. In modern construction these bearings are in the form of bushings which may be replaced at small expense. The brake linkage has many bearings, which are clevis and pin. These are non-adjustable, and unfortunately are not often lubricated. When wear occurs the holes may be drilled larger and larger pins be inserted, or the parts may be replaced entirely.

Of course there are scores of other bearings in other parts of the chassis, that with ordinary care last the life of the car. The lubrication and adjustment are usually given in detail in the manufacturer's book of instructions and need no special caution other than to advise following what is there printed.

CHAPTER XXV

DRIVING THE CAR

It takes more than a knowledge of certain small levers and pedals and a deftness in manipulating clutch and brakes and gear shifts and steering wheel, to make an automobile driver. Because of this fact the Automobile School of the West Side Young Men's Christian Association, in New York City, has formulated a set of instructions to its students for the road lessons, which are about the most complete, yet concise, so far published. They are copyrighted and published by permission. It may emphasize the foregoing chapter to first quote the introductory paragraph which otherwise would have been omitted.

> The following applies particularly to the cars used in the school. Slight variations may be found on other machines, so it is well to get an instruction book from the manufacturers of the car you expect to operate and follow their instructions closely.

Before Leaving the Garage—See that there is sufficient gasoline and oil in the tanks to carry you the distance you wish to go. Examine the radiator or tank to see that it is full of water. Have sufficient air in the tires. All grease cups should be filled and turned down properly. If batteries only are used, two should be carried, and one of them fully charged. If you are carrying only one battery, be sure that it is sufficiently charged to make the desired run. Have on the car at least one extra shoe and three extra tubes, with the ordinary equipment of tire pump, jack, oil gun, tire tools, tire patches and cement, and the regular kit of other tools. A set of non-skid chains will be found very useful on wet days; in fact it is not safe to run without them on wet asphalt. They should not be used however any more than is necessary, as they wear the tires excessively. A couple of extra spark plugs should be carried to save the trouble of cleaning a short circuited one on the road.

Starting Crank—In a gasoline automobile, it is found that the motor must draw a supply of gas into the cylinder and compress it before this charge can be ignited to expand and give power. It is therefore necessary to have some means of turning the engine over to accomplish this. The starting crank placed usually on the front of the machine, just in front of the radiator and between the front spring horns, is for this purpose. It is operated, as a rule, with the right hand, and is rotated clockwise (the direction the hands of a clock travel). When there is a self-starter provided, the starting crank is carried in the tool box, and is used only when the starter will not operate.

Starting Pedal—The starting pedal or button may generally be found somewhere on the floor board. Pressing on it connects an electric motor to the crank shaft of the engine and closes a switch that allows current from the storage battery to flow to the motor and crank the engine. This takes the place of the hand-starting crank.

Clutch Pedal—It is quite often desirable to run the engine without moving the car, and it will also be found necessary at times to bring into mesh different gears so that more power or speed may be obtained. A clutch is, therefore, placed between the engine and the rear wheels. It is controlled by means of a pedal placed just back of the dash. The clutch is released by pressing on this pedal with the left foot, and when released the engine will continue to run, but will not deliver power to the driving wheels. When the pressure of the left foot is released from the pedal, the clutch will become engaged automatically by means of a stiff spring and the car will move forward or backward, according to which gears are in mesh. If the gears are in the neutral position, however, power will not be applied to the car when the clutch is engaged. The clutch must be released every time the gear-shifting lever is moved and whenever the brake is applied.

Remember, it is **depressing** or **pushing** this pedal that overcomes the tension of the spring and **releases** the clutch, and when no pressure is applied to the pedal, the clutch is **engaged.**

The Running-Brake Pedal—The running brake is used for bringing the car to a standstill. It is operated by means of a pedal placed just back of the dash and to the right of the clutch pedal. To apply the brake, first release the clutch by pushing on the clutch pedal, then push down or forward on the brake pedal with the right foot gently but firmly until the car is stopped. After removing the foot from the brake pedal the brake will be released automatically by means of a spring. Use the brake gently to save discomfort to the passengers, wear on tires and the machine in general. Do not run close to the point where the stop is to be made and then jam the brake on hard, but begin to apply it early and bring the car to a standstill gradually.

The Emergency-Brake Lever—The emergency brakes are used chiefly after the car has been stopped and the operator wishes to leave it. They are applied by means of a lever operated by the right hand. This lever is usually placed just forward and to the right of the driver's seat. It is fitted with a spring latch and when applied will lock on, and so is very convenient in stopping on a hill or when the car is left standing at the curb. The brake is applied by pulling back the lever. This brake can be used alone or in connection with the running brake for quick stops when necessary, but it should not be used for ordinary stopping as it is usually not designed for such work.

Gear-Shifting Lever—This lever is usually placed forward and to the right of the operator's seat, and to the left of the emergency-brake lever. It is operated with the right hand. By shifting this lever which engages different sets of gears, the machine may be made to go forward at different speeds while the engine turns at a practically uniform speed. It also controls the reverse gear.

When the car is standing, the lever should be left in neutral position. When in this position, even if the clutch is engaged, the machine will not move. To start the car, release emergency brake, release the clutch with left foot, grasp the gear-shifting lever with the right hand and shift from the neutral position to the first speed notch, accelerate slightly, then allow the clutch to engage slowly and the car will start. After the car has started, release the clutch again and shift the gear lever to the second speed notch and engage the clutch quickly but gently. Repeat this operation for third and fourth speeds. **Always release clutch when shifting this lever.** Whenever the car is brought to a standstill, put the lever in the neutral position before applying emergency brake.

Accelerator Pedal—This pedal operates the throttle on the carburetor and regulates the amount of gas going to the engine and thus controls the power which the motor develops. It is sometimes placed between the clutch and brake pedals, but usually to the right of the brake pedal and is operated by the right foot. More gas is permitted to enter the cylinders and therefore more power is obtained by pressing on it, and when released the throttle will be returned to its minimum position by means of a spring. Push on the pedal very slowly, for a slight movement greatly increases the power developed by the motor and a too sudden application of power will strain the whole machine. It should be pushed slightly when the clutch is engaged to increase the power of the motor, and should be released when the clutch is disengaged, so that the engine will not race.

The Throttle Lever—This lever controls the throttle on the carburetor the same as the accelerator pedal but it has a spring latch, and when it is desirable to run the machine for some distance at a nearly constant speed, this lever may be used as it will stay where placed, thus relieving the right foot which would become tired of holding the accelerator pedal in one position for a long time. It is usually placed on the steering post above the steering wheel and is operated with the right hand. **Do not advance throttle lever too quickly.**

The Spark-Control Lever—It takes some time after the spark occurs for the gas to get thoroughly ignited and give power. It is therefore desirable to have the spark occur earlier when the engine is running fast, so that the gas may be thoroughly ignited at the beginning and deliver power for full length of the working stroke. This means that the spark when advanced actually occurs when the piston is still traveling up on the compression stroke and so gets the gas in the cylinder at its maximum pressure when the crank passes top dead center. When the motor is cranked in starting it is turned so slowly that to avoid a kick back the spark must be retarded so that it occurs after the crank has passed top dead center. The spark-control lever is connected with the spark-timing device, and so controls the time at which the spark occurs in the cylinder. It is usually placed on the steering column above the steering wheel, and is operated with the right hand. On some cars it is moved forward and on others backward to advance the spark. When the engine is cranked in starting, the spark should be fully retarded. After the motor has started it can usually be advanced about two-thirds, but there is no set rule for this. In general, advance as the motor (not the car) gains speed and retard as it slackens speed. Keep the spark advanced as far as possible at all times but retard it if the engine labors or knocks.

Ignition Switch—Usually placed on the dash. It is for the purpose of closing and opening the electric circuit and thus stopping the motor or allowing it to be started. It is generally provided with a removable plug or a key so that the car may be safely left at the curb. Be sure that switch is in "Off" position when the motor is stopped.

Steering Wheel—The steering wheel is usually placed on the left-hand side of the car directly in front of the operator's seat. By its means the direction of the car is controlled. When moving forward, turning the wheel counter clockwise will cause the car to go to the left and turning it clockwise will cause the car to go to the right. It should be operated with the left hand only unless steering is very hard, when both hands may be used. Grasp the wheel firmly with one or both hands but not with a strong, nervous grip, as this becomes very tiresome. If the hand is kept always in one position on the wheel when only slight turns are desired, there will be no difficulty in knowing by its position when the front wheels are pointing straight ahead. When turning corners the position of the hand on the wheel may be changed and both hands should be used. Do not attempt to turn the steering wheel when the car is not moving as this throws a very great and entirely needless strain on the whole steering mechanism.

Priming Device or "Choke"—When the engine is cranked in starting, it is turned so slowly that the air going in through the carburetor has not sufficient velocity to draw the required amount of gasoline from the spray nozzle. The mixture that goes into the cylinder is therefore weak and cannot be exploded easily. To enrich the mixture, a valve is placed in the carburetor air passage, to choke off the air and feed more gasoline to the motor. This valve is operated by a lever or button usually found on the dash or attached to the steering column under the steering wheel. It is often combined with a device for making the mixture richer or leaner to take care of different weather conditions. Some engines will start nearly every time without priming the carburetor; others must be primed every time the engine is started. Do not prime to excess; as soon as the engine starts, return the lever or button to the running position.

The Gasoline Tank—The gasoline tank carries the fuel that is to be fed to the engine. It will sometimes be found under the front seats, and may be filled by removing the cushion. In this system the gasoline flows by gravity to the carburetor and a small hole about the size of a pin will be found in the filler cap to allow the air to enter as the gasoline leaves. This hole should be kept clean, because if the air cannot enter the gasoline will stop flowing to the carburetor and the engine will stop running. Some cars carry the gasoline tank on the rear of the chassis under the body and air pressure is kept on the gasoline to force it to the carburetor. This pressure is obtained by a hand pump placed on the dash, and is kept constant automatically. This system differs from all others in that there should be no hole in the filler cap of the tank and the gasket on the cap should be kept in good condition to prevent air leakage. A gauge will be found on the dash and by this means the pressure on the tank can be determined. Other cars with the tank under the rear end of the chassis have a system of drawing the gasoline by means of a vacuum, to a small tank located by the carburetor under the hood, from which it flows into the carburetor by gravity. Still other cars have a gasoline tank in the cowl of the dash from which the gasoline flows to the carburetor by gravity.

The Lubricator—The lubricating system is generally built into the crank case of the engine. The oil is supplied through a pipe or other opening found on the engine and a gauge or pet cock is provided to indicate the amount of oil in the motor. The system should be kept filled with a light to medium high-grade gas-engine oil. The lubricating system usually oils all internal parts of the engine only, the transmission, steering and differential gears being lubricated by heavy oil or grease placed in their respective housings, and all other parts of the car are taken care of by oil or grease cups. Any oil put into the engine should be carefully strained to remove dirt or grit.

The Water Tank—The water tank or radiator is placed on the front of the car and should be kept filled with clear water. Any sediment that is allowed to enter the radiator will clog it and the engine will then overheat. During the winter it is well to fill the radiator with some anti-freezing solution. Alcohol is good for this purpose, mixed with water in the following proportions as desired.

2	pints wood alcohol to 1 gallon water freezes at 0° Fahr.
2½	pints wood alcohol to 1 gallon water freezes at 10° below
3	pints wood alcohol to 1 gallon water freezes at 20° below
4	pints wood alcohol to 1 gallon water freezes at 38° below

If steam is discharged from the radiator, examine the fan directly back of it and the water pump, and see that there is no clog in the pipes leading to and from it.

Tires—Keep the tires free from oil and grease as they rot the rubber. Drive very carefully in wet weather because rubber cuts very easily when wet. Drive slowly around corners and start and stop without jerks; also be very careful not to rub the tires against the curb. Have all small cuts vulcanized so that moisture cannot get in and rot the fabric. Do not run on a flat tire unless it has been damaged beyond repair. Run slowly on the rim or wrap rope around it if no other tire is to be had. It is very important to keep the tires fully inflated at all times. If tires do not give satisfactory wear report it to the manufacturer at once. When the car is to be laid up for some time, place jacks under it to keep the weight off the tires.

To Start the Motor—Place the gear-shifting lever in the neutral position, put the emergency brake on, retard the spark fully or if well acquainted with the motor, to a point where the spark will surely occur after the crank has passed top center. Open throttle about one-third. (After getting acquainted with the machine you will find a position for the throttle where the motor starts best.)

Put the switch in "On" position. If the motor habitually starts hard, prime the carburetor with choking or enriching lever. If car is equipped with electric self-starter, press hard on starting button or pedal. When the engine starts, remove foot from pedal immediately, then close throttle and advance spark lever two-thirds. In cranking the motor by hand, grasp some part of the car with the left hand to steady yourself, place the feet wide apart, and stand close to the front of the machine. Grasp the starting crank with the right hand having it at its lowest position, or a little to the right of this point. Push the crank in as far as it will go and turn slowly clockwise until it engages the crank shaft. It will usually catch when about at its lowest position. When engaged, brace yourself firmly and pull up quickly on crank, turning it about one-half revolution. If after repeating this operation several times the engine does not start, it may be found necessary to spin the motor. This means cranking for a full revolution or more. In spinning the motor, care should be taken to always start with an up pull so as to gain momentum for the down thrust and so reduce the danger of a kick back to a minimum. After the engine starts, advance the spark about two-thirds and close the throttle. If the engine has been started on the battery and a magneto is used, switch immediately from the battery to magneto. Do not allow the motor to race. When running idle, it should turn over at its slowest speed.

To Start the Car—Take your place in the driver's seat, place left foot on clutch pedal, and press hard to release the clutch. Keep it disengaged while with the right hand the emergency brake is released and gear lever is shifted from neutral to the first speed notch. Then with the right foot press the accelerator pedal gently until the motor speed is increased a little and at the same time with the left foot allow the clutch pedal to come back, until the clutch starts to engage and the car begins to move. From this point decrease the pressure on the clutch pedal very gradually until the clutch is fully engaged, at the same time listening to the engine to see that it doesn't slow down sufficiently to stall. If it shows signs of stalling, press accelerator pedal a little more to increase its speed, at the same time keeping a slightly greater pressure on the clutch pedal. Stalling the motor is the result of feeding too little gas with the accelerator, or of not keeping pressure on the clutch pedal during the time the clutch is engaging. The jerking of the car comes from feeding too much gas and engaging the clutch too suddenly. Both of these faults may be overcome by listening to the speed of the engine and keeping it right through the proper use of the accelerator pedal, and by releasing the pressure of the foot from the clutch pedal very gradually from the time it starts to engage until it is fully engaged. It is impossible to become a good driver until the ear learns to judge the speed of the motor by its sound and the left foot learns to engage the clutch gradually. When the clutch has become fully engaged, press accelerator pedal slightly to speed up the machine. As soon as it has attained fair momentum, release the clutch and at the same time let up on the accelerator pedal. Change gear lever immediately from first speed notch to second speed notch and let in the clutch quickly until you feel it take hold and then gradually, at the same time pressing slightly on the accelerator pedal. *When the clutch pedal is pushed out, the accelerator pedal should be released; when the clutch is let in, the accelerator pedal should be pressed slightly.* Change from second to third and from third to fourth if four speeds are employed, always releasing clutch when gear is shifted, and always accelerating slightly while the clutch is being engaged.

Do not forget that the clutch is released when the clutch pedal is pushed out, and that it is engaged when the pedal is allowed to come back. Run on the high-speed gear as much as possible, and when it is necessary to drive more slowly release the clutch and apply the brake gently until the car is brought to the desired speed. Then if the speed of the machine is low enough to warrant it, release the brake and, with the clutch still disengaged, change from the high to the next lower speed notch and let in the clutch. If the car has lost much momentum it may be necessary to change to the lowest gear before letting in the clutch, otherwise the engine may be stalled. Do not drive too close to other vehicles or objects before releasing the clutch and applying the brakes as the brakes may not hold as well as you think and you may not be able to operate them correctly when in close quarters. If while the machine is standing it is found impossible to move the gear lever from neutral to first or reverse, leave the lever in neutral, allow the clutch to engage slightly, then release it quickly and shift lever to desired notch.

To Stop the Car—Select a lamp-post, tree, or other object along the curb, and when still some distance from it, disengage the clutch and apply the brake gently and get the car under control so that you can, if you wish, stop ten feet before the object is reached. Then, releasing the brake pressure slightly, allow the car to drift to the object, stopping with the rear door directly opposite the object and the car close enough to the curb to allow passengers to alight on the sidewalk. Shift gears to neutral, apply emergency brake, and allow clutch to engage. Be careful that the tires do not scrape along the curb as this is very damaging. The brake should be applied so that the car is not brought up with a jerk. This can be accomplished easily with a little practice, as can also starting of the car. Remember that you are driving for the comfort of the passengers, and they can feel the jerks and jar much more than you.

To Reverse the Car—Bring it to a standstill first, then with the clutch released place the gear lever in the reverse notch. Allow the clutch to engage gently with the left hand only on the steering wheel, look backward and gauge the direction by the rear end of the car. Do not attempt to steer by watching the front wheels; always look to the rear when going backward, to make sure the way is clear.

Turning in Narrow Streets—With the car moving slowly, first look back to see that there is no other vehicle coming and then turn the wheels sharply to the left as far as possible. When within five feet more or less, depending upon the speed of the car, of the left-hand curb, release the clutch and apply the brake gently, at the same time turning the steering wheel quickly to the right.

Stop turning the wheel when the car is brought to a standstill. With the clutch still released and the brake on, shift to the reverse gear. Then release the brake; accelerate slightly, let the clutch in carefully, and when the car starts to move continue turning the wheel to the right or clockwise. This will point the car in the opposite direction. When going backward look toward the back of the car and also up and down the street to see that no other vehicle is approaching. After the car has traveled back a sufficient distance, release the clutch, take foot off of accelerator pedal and apply brake, at the same time turning steering wheel to the left until the car stops. Then with the clutch still released and the brake still on, shift from reverse gear to first speed gear. Take right foot from brake pedal and accelerate slightly, allowing clutch to engage gradually, and as soon as the car starts to move, continue turning steering wheel to the left until the car goes straight ahead. Do not turn the steering wheel while the car is standing. Start to turn when the car begins to move. Do not allow tires to strike curb.

Turning Corners—Before turning a corner hold out the hand so that any driver behind you may see it, and also look back to make sure that he does see it. If another vehicle is close behind you or if there is one in front coming toward you, slow up your car and wait until it has passed before turning. When turning a corner to the right keep as close to the curb as possible so that the car will be on the right-hand side when you get into the side street. When turning to the left go past the center of the street into which you are traveling and then turn sharply, so that you will be on the right-hand side of the road. Do not cut close to the left curb. Always go around a corner at a low enough speed to make the use of the second speed gear necessary, and reduce speed so that the gear shifting must be done before starting to turn, not after, as this gives better control of the car. Turning corners at a high rate of speed puts a great strain on the tires and causes them to wear excessively. It is also uncomfortable for the passengers. Use both hands on the steering wheel, and if the car is found to be going too fast check it by releasing the clutch and applying the brake slightly. Do not shift gears before slowing the car. The idea is to slow the car sufficiently to make shifting to a lower gear necessary.

Climbing Hills—When approaching a hill accelerate and advance the spark, as speeding up the motor makes it more powerful and adding momentum to the car will often carry it over hills that would need an intermediate speed gear if an attempt is made to climb them slowly. As the hill is reached, open the throttle fully. If the engine begins to feel the grade and labors or knocks, retard the spark until the knocking or laboring ceases. If the hill is a very steep one, as soon as the engine begins to lose speed, release the clutch, remove pressure from accelerator and, without applying the brake, shift to a lower speed gear. Let clutch in quickly and at the same time open accelerator wide. It will then probably be found that the spark can be advanced without causing the engine to knock. On some hills it may be found necessary to shift to the first speed gear, but this should not be done unless the engine will not pull the car on a higher gear. When gears are shifted on a hill the change must be made quickly and the clutch let in immediately, as slow work will allow the car to lose momentum, and then when the clutch is engaged the engine will stall. If the engine stalls, put on the emergency brake and put gear lever in neutral notch. It will be well to place a stone or block back of the rear wheels before cranking the motor as the vibration of the engine may jar the emergency lever loose. In starting again, release the clutch, put lever in first speed gear, accelerate strongly, release the emergency brake and at the same time let the clutch engage. This must be done quickly, otherwise the car will start to back down the hill. With some cars it may be found easier when starting from a standstill on a steep hill, to apply the foot brake, release the emergency brake, engage the clutch while the foot brake is released gradually, at the same time feeding gas to the engine with the hand throttle. Do not attempt to climb steep hills until you have thoroughly mastered shifting gears on the level.

Descending Hills—When descending slight grades throw off the ignition switch and leave the gear lever in high speed with the clutch engaged. This will cause the engine to act as a slight brake and if necessary the running brake may be operated in connection with it. There is no harm in applying the brake under these conditions with the clutch engaged, because switching off the ignition causes the engine to stop giving power. When a very steep grade is encountered, before attempting to descend it, stop the car and shift to second or first speed gear. The lower the gear used the greater will be the braking power, and when first speed is used it is almost impossible for the car to get beyond control. The ignition may be switched off or on as the occasion requires. Switching it off gives greater braking power. The clutch must be left engaged, and the brakes may be used to help. It is well to use first one brake and then the other in descending long grades, as too long an application of one will cause it to heat and burn the friction material. Do not wait until you are half way down the hill before finding out that it is too steep for the brakes to hold the car. Make up your mind before starting to descend and shift to first gear if necessary. Do not allow the brakes to get in such condition that they will not hold to the best of their ability. Never descend the hill at a high rate of speed no matter how safe it looks. Brakes do not hold as well when the car is going fast as they do when it is moving slowly, nor will they stop a car as quickly going down a grade as they will going up.

Driving in Congested Streets—Procure a copy of the rules of the road of the city in which you are driving and obey them. Keep to the right-hand curb unless it is lined with standing vehicles, in which case keep close to them. In overtaking another vehicle, pass it on its left. In passing a vehicle coming in the opposite direction go to the right of it. When stopping, the wheels must be within six inches of the curb. Before stopping, hold your hand out at the side of the car to warn the man who may be behind you. Do not at any time slow down or stop without holding out your hand and looking back to make sure that it is seen. Pedestrians have the right of way at crossings, but you may warn them of your approach by blowing the horn. However, do not make a nuisance of yourself by using it more than necessary. When traveling in a side street, upon coming to a main thoroughfare slow up so that you can stop quickly, as vehicles on these streets have the right of way. When on a main throughfare it is not necessary to slow up at every cross street. Watch the traffic policeman, and when one holds up his hand, stop; first holding out your hand to warn anyone behind you. Remain standing until the policeman motions you to proceed. In some places the policemen use whistles instead of motions, and the signals used by them should be learned. Whenever it is necessary to reduce the speed of the car considerably, release the clutch and apply the brake. When the car is going slow enough, shift to a lower speed gear to prevent stalling the motor when the clutch is let in. When it is found necessary to keep behind a slow moving vehicle, shift to a speed so low that it will not be necessary to slip the clutch. If it is desirable to go slower than first speed gear, however, the clutch may be slipped by keeping a slight pressure on that clutch pedal. A great variation in speed may be obtained when in any gear by the proper manipulation of the spark and throttle levers.

Do not attempt to keep pace with other vehicles until you are an experienced driver. When in close quarters, perform every operation slowly as a move made slowly but surely will probably take less time than a move made incorrectly. There is no occasion for getting excited, as it is safe to assume that every other vehicle is under perfect control.

Learn to shift gears without looking at the lever, because you will need your eyes to watch the road. Sit straight in the seat: do not get hunched over the steering wheel as this indicates a novice. Always drive into the garage on the first speed gear.

Washing the Car—The car should be washed immediately upon coming into the garage, before the mud has had time to dry. Do not scour off the mud as this scratches the varnish. Use the hose with a slow stream until the mud is well loosened, and then finish by soaking (not rubbing) off with a sponge well wet with water. Where a hose is not procurable the mud may be loosened with a wet sponge and then washed off entirely by throwing pails of water on it. Be careful that water does not go through the radiator or any other opening and get on the engine, as this is likely to short circuit the magneto or spark plugs and prevent the motor from running. If there is grease on the car, soap must be used to remove it. Castile soap is the best for this purpose. However, do not apply the soap itself to the car, but make suds in lukewarm water. After all mud and grease has been removed, wipe dry with a chamois skin. Wash and dry the body before the running gear, and be careful that no grease is collected on chamois from wheel bearings and steering-arm joints.

Cautions—Don't twist the steering wheel when the car is standing. Corners should be turned at slow speed to save wear on tires. The brakes should not be applied with too much force except in an emergency, as it is hard on tires and the machine in general. Don't let the motor labor or knock when ascending hills. When going down long hills use one set of brakes and then the other. Shift to first speed gear before descending steep hills. Change from first speed to reverse and from reverse to first only when the car is standing. Be very careful of skidding on wet pavements. Put non-skid chains on for wet or icy roads. Always start and stop the car without a jerk. This constitutes good driving. Don't forget to see that the license pad is attached before leaving the garage. Inspect oil, gasoline, and water tanks before making a trip and see that the necessary tools and extra tires are in the car. Don't let the car stand with the motor stopped in the winter time, unless the radiator is filled with anti-freezing solution. Look the car over thoroughly after each run.

The records of the examinations held at the school show that there are a few points of driving which a large majority of the students do not entirely master. This is not due to lack of instruction in the subjects, but is rather the result of poor memory or insufficient practice. Failure to perform these operations perfectly does not necessarily mean that the student is not a safe driver, but it does show that he needs more practice before being rated as an expert. If you want to be a little better than the average driver, keep in mind the following points, go back and read them over again in this booklet, think about them when driving the car and try your best to master them.

When about to turn a corner, or turn in a street, or in fact whenever swerving from a straight line, look back to see if it is safe to make the turn, and hold out your hand to signal what you intend to do.

Make sure that the spark is retarded, the gear lever is in neutral, switch on, and other levers in their proper positions before cranking the engine.

When the car has been slowed down to a very low speed for any reason, shift to a lower gear; don't try to pick up speed on high gear. Don't shift to a lower gear until the car speed has been reduced sufficiently.

In New York City, traffic traveling north and south has the right of way, therefore when crossing an avenue go slowly and make sure you will not cut off vehicles on the avenue.

When starting the car, allow the clutch pedal to come back until the clutch begins to engage, then keep enough pressure on the pedal to allow it to become fully engaged very gradually. Letting the clutch engage all at once makes the car jump or the engine stall, and observers smile knowingly. In this connection you should listen to the engine and operate the clutch and accelerator so that the engine is not raced or stalled.

CHAPTER XXVI

WHERE EXTRA CAUTION IS NECESSARY

It would seem unnecessary to give caution to the motorist where there is an element of safety involved; it ought to be understood that everyone entrusted with the wheel of a motor car would be interested in his personal safety and in the safety of those in his keeping, and that he would take all ordinary and even extraordinary precautions to keep skin unscratched and bones unbroken and existence preserved. But it is a fact that for a large proportion of motorists there is no such word as "Danger," and no such word as "Care." Why is it?

For some reason there is abroad the spirit of "take a chance," and it has entirely superseded the cautious foresight which was once the American nature. Perhaps it is the changed conditions of our land which is responsible for this. In pioneer days caution was necessary, for one did not know behind what tree or rock lurked death in the form of a savage, and there were wild animals to avoid in the forests, and even along traveled highways; so that to look ahead, to watch for signs of danger, and to approach points of peril with every sense alert, was second nature.

Boys who were brought up to tramp the woods or prairies were alert also, because of hiding snakes and prowling wolves, and because of the need for keeping track of distances and locations to prevent being lost. We are only a generation or two from these things even at the crowded centers of population; but the last two generations which have grown up in the city, and millions who have come from other lands in the same period have not this inbred caution. Men who are in peril daily from one cause and another incident to city life, and "nothing happens," cannot be expected to get excited about possibilities, which in time become so familiar as to breed contempt.

The man who is in constant fear lest something fall from a tall building upon him, or there be an explosion from beneath, or a crash of trolley, subway, or elevated cars, with a generous complement of fire and flood and gale added, would go crazed if he thought much on these things. Therefore it is hard to get him to think of "safety first." It is rather "I should worry," and it actually prolongs life, so long as it is applied to familiar things—it keeps nerve systems from breaking.

This is why it is so hard to get the city driver accustomed to caution in places of real peril. One of the worst of these is driving over railway tracks. Out on the Huckleberry division, where there is but one train a day each way if luck favors the intending passengers, there is not so much danger; but in the vicinity of all the large cities where suburban trains run often and through trains are numerous, it behooves the autoist to acquire speedily a belief in signs. The usual sign at a railroad crossing is a post with two arms in the form of an X to warn highway travelers. It matters not that there is a flagman or gates, a due sense of caution is necessary for the driver of an auto.

The railway near the writer's old home had signs reading: "Stop, Look, Listen"; and this should be the slogan of the driver nearing a railway crossing today. In spite of the ringing of engine bells and blowing of locomotive whistles and of other precautions of the railway company, it is incumbent upon the motorist to be careful, to know that there is no train approaching. An automobile may be stopped within a few feet and the train sometimes takes a quarter of a mile for a stop; therefore the motorist should not trust to the stopping of the locomotive, for by that time it might be everlastingly too late. Better stop the auto at every crossing if the noise of the motor prevents hearing whistle or bell signals from the train.

But there is a worse dereliction than failing to make sure that a train is not at hand, and that is the devil-may-care spirit which prompts driver to spurt up the engine and dash for the crossing to get over ahead of the train that is in plain sight. There are few persons who can estimate the speed of a railway train with any degree of accuracy, even the railway employes having to check the time between known points to estimate the speed, unless there is a speedometer. The autoist, looking at a coming train, sees it at an angle which prevents his comparing it with fixed objects and cannot tell if it is running ten or sixty miles an hour as a rule.

It does not do any good to talk about rights and failure to hear a warning after the final ceremonies are over and the cemetery has another monument, and the writer would much prefer to be a live snail than a dead hare, and would agree to make his destination first, as well. Neither will it do to talk about the fool-killer and his good work; sometimes others than the foolish driver are imperiled and suffer. There is only one way to regard it and that is to resolve to observe the ordinary rules of caution and to make sure that one is not trying to occupy the same space as a railway train at the same time. The train has might, if not right, you know.

Equally important are the crossings of trolley lines, in these days of high-speed trains and cars, and quite as many accidents occur at street intersections where two main lines of travel cross, even though there be no trolley lines. It takes so little effort and so little loss of time to slow down until one can see the way clear, when there is no traffic man at the crossing.

But if one needs be careful of his own hide, it is quite as important that he be careful of the other fellow's anatomy. It is easy to say of the pedestrian, or the man in another vehicle, let him keep out of the way, or keep to his own side of the road; well, if he don't, you can keep out of his way and you will be a great deal happier at the end of your trip than if you disregard him and there is an accident. One hardly likes to contemplate even an unavoidable injury to another.

It must be remembered, also, that the pedestrian has rights upon the highway greater than the auto driver. It is popular to talk about the "jay-hawker" and to assume that the man on foot has few rights in the road, whereas he has the first right, according to the United States Supreme Court, and no amount of traffic rules and ordinances and laws can affect his right. Without respect to the wisdom of his doing it, the man afoot has the right to travel in the middle of the road if he cares to, and it is the duty of the driver to keep out of his way. Remembrance of this may save the driver damages in large amount, for the courts will assess the careless driver, or the careful driver for that matter, if the pedestrian is hurt and asks damages.

CHAPTER XXVII

AN AUTO FURNACE FOR WINTER

HAVE you a little hot air furnace on your car? You need one on frosty mornings unless you want the engine to act as though it had an acute attack of bronchitis for half or three-quarters of an hour. Maybe you'll also need to get out the teakettle and some more extras to get started in proper shape. A lot of men borrow their wives' dishrags also to help start the cars. Great help, too.

There is not a bit of foolishness about this as the man who has a car will appreciate, if he has tried to start it with the temperature down at the freezing point and a wind blowing that would carry off the engine heat so fast the metal would remain cold. Probably most other folks have noticed that a lot of cars sputter and cough and spit and pop as though all kinds of trouble were going on inside, and the experienced ear can detect many a six-cylinder hitting only on two of the cylinders, while many a flivver is chug-chugging away like one of the old one-lungers of ancient auto days. Not only is this at the start, but for blocks and even miles.

Now to a novice, the new owner, the first inclination would be to cuss the manufacturer and the engine. It isn't the fault of the engine at all; it is because "the gasoline doesn't gas." However there is a solution of the problem, at least enough of a remedy to make life a little happier for the owner.

This condition of gas was absent for several years. In the early days of automobile construction, before the manufacturers were able to devise a carburetor for vaporizing gasoline under all conditions, we had this same trouble as soon as the weather turned cold. Persistent experiments produced a carburetor which overcame the trouble. Then almost as soon as a carburetor was developed which would vaporize the gasoline under adverse conditions, somehow the volatility of the gasoline was found to have decreased.

You will remember the contest between armor plate and big guns—as soon as an impenetrable armor plate was invented, some genius would go ahead and find a powder or gun which would shatter the impenetrable plate. Then the armor factory would try to find something to outwit the gun maker. That is the way with carburetor and gasoline. It is time for the carburetor maker to devise a scheme to volatilize the heavy gasoline now supplied under all conditions—particularly in cold weather. There are signs that he is matching up to the emergency.

It is true that the gasoline now sold has a greater heat-producing quality, if only we can get it properly mixed and volatilized. It may be that the gasoline producers, by putting heavier gasoline on the market, have been of a real service to auto men, once we have learned to utilize it economically and efficiently. They may have had in mind the higher power, but they have given us a gas which is very hard to vaporize on a frosty morning. Sometime soon, probably the carburetor man will catch up and give us a vaporizer which will handle it. Until they do, we will have to look for means of overcoming the difficulties now experienced, and it is largely a question of warming up the air.

In changing gasoline from liquid to vapor, considerable heat must be supplied. When the atmospheric temperature is too low, there is not sufficient heat in it to vaporize the gasoline sprayed into the carburetor. When the engine is warm, the process of vaporization goes on from the needle valve to the moment of ignition, but if the engine is cold, the process is retarded more or less, and under some conditions it is possible for thoroughly vaporized gasoline to be again condensed. The man who does not understand is inclined to say uncomplimentary things about the engine and talk about "fireproof gasoline." The only trouble is that the temperature is so low that we must heat the air before we send it into the carburetor. Practically all the carburetor manufacturers put out a "stove" to heat the air supply, which is attached around the exhaust pipe, so that the hot air surrounding the pipe is conveyed to the carburetor, which warms the air entering the intake, thus supplying the heat necessary to effect vaporization. This "stove" or gas warmer, the chauffeurs are beginning to call a "hot-air furnace."

The process of vaporization absorbs a large amount of heat. To raise the temperature of the liquid one degree takes a certain amount of heat. The amount required per degree remains the same until the point of vaporization is reached, when two hundred times that amount of heat is required to effect vaporization. The "hot-air furnace" supplies the extra amount of heat.

A great many carburetors have the mixing chamber water-jacketed and the water from the cooling system is circulated through it, supplying some heat in that way. Sometimes that in itself is sufficient, but at present it seems advisable to use both. Neither one of these is in operation when the engine is started; the "hot-air furnace" depends upon the exhaust pipe being heated, and the water-jacket upon the engine itself being heated long enough to warm up the circulating water. So that it becomes necessary to find some means to supply heat until these warm up.

When the car is started in a warm garage the gasoline will vaporize properly and the engine will run in good shape, but as soon as the car goes out into the cold air it will cool the engine so that some of the gasoline will be condensed. Therefore we close the radiator cover partly or wholly until the engine is thoroughly warmed. If the car is started in a cold garage, the teakettle and dishrag method must be resorted to. Wrap the cloth around the carburetor so that it does not cover the air intake, and pour the boiling water on the rag, taking care that none gets in the air intake. The hot water will heat the carburetor and intake pipe and raise the temperature of the mixture so that the engine will run. In some cases it may be necessary even to drain out the cooling system and fill it with hot water, so that the combustion chamber becomes heated up.

As the weather becomes colder it will be found necessary, no doubt, to close up the radiator more and more in order to keep the engine at the required temperature. High engine temperature, up to the point where the water in the cooling system begins to boil, is desirable from the standpoint of efficiency, and if no trouble is experienced with irregular running, the hotter the engine is, the larger amount of power is developed.

One manufacturer has incorporated in the radiator a shutter-like device, by means of which the amount of air admitted may be regulated from the driver's seat. Doubtless others will follow, or find an equally good substitute.

Radiator covers to fit almost any car now made may be procured at trifling expense; one may simply put a piece of cardboard over it. Being out without a cover recently when the engine did not work right, the author stopped when he came to a newsboy and bought a paper and tied it over the radiator, getting home all right with this substitute.

One man complained that his car would start out well and run all right as long as he was going away from home, but as soon as he turned homeward it would begin to act up. He wanted to know if the car had the wanderlust. Inquiry developed the fact that the trips he spoke of on the going trip were with the wind and returning against it. The added force of the wind over the engine cooled the engine too much, and he was advised to cover the radiator under such circumstances. He reported no trouble after trying it.

Of course, sometimes, the skipping can be overcome by enriching the mixture by the dash control, but with the present heavy gasoline the enriched mixture does not seem to do much good and is simply adding to the supply of gasoline which already is refusing to vaporize. Therefore it seems to be the stove and the dishrag for the cold engine.

CHAPTER XXVIII

THE COOLING SYSTEM IN WINTER

WHILE there are many sections of the country where it is necessary to put the car away for that portion of the year when the ground is covered with snow and ice, and for that reason many cars are put in storage, yet there are sections where this is not necessary. And likewise, in the Northern cities, where the snow is cleared from the streets after every storm, the improvement in carburetors and the adoption of heating devices have made it possible to keep the car in commission where formerly it was thought impossible.

There are two things necessary if the car is to be operated in winter, the first of which is some anti-freezing solution for the cooling system; the second is a device for warming the mixture before admission to the cylinders.

Many things have been tried for making the cooling system freeze-proof. The most common are salt, glycerin, and alcohol. Any one of these in the proper proportion will insure against freezing. They are not equally desirable, however. Salt has a tendency to set up electrolitic action where iron and brass parts are combined in the cooling system, but four pounds of salt to the gallon will give a solution which will not freeze until seventeen degrees below zero, Fahrenheit, is reached. Glycerin will keep the water from freezing, but it is expensive and if rubber hose is used to connect radiator and the cylinder pipes, glycerin will cause it to decompose rapidly.

Denatured alcohol probably is the best to use, mixed with water in proportion as the cold to be expected may demand. Twenty per cent. of alcohol will give protection to five degrees above zero; thirty per cent. to nine degrees below zero, and thirty-five per cent. to sixteen degrees below. The owner must not make the error of using a mixture which will protect him only for the average low temperature of his locality. For thirty years the average minimum for the vicinity of New York City was twelve degrees above zero. The man who thought he was playing safe with a twenty-per-cent. solution would have ruined his engine on one of the days while this material was being prepared, for the temperature went to twenty below in the suburbs and to seventeen below in the city. Unless the owner had foresight enough to drain out the cooling solution there would have been burst radiator and pipes, and perhaps a cracked cylinder, or at least the water-jacket, to be replaced. Even a thirty-five per cent. solution would not have saved the damage.

Probably a combination of alcohol and glycerin will suit the particular owner a little better than alcohol alone, since there is less evaporation, and a single dose of glycerin will last the entire season, only alcohol and water needing to be added to replace that boiled away or evaporated. Half alcohol and half glycerin is the proper proportion to be added to the water. It has one advantage, that it freezes quite a bit lower than the alcohol alone. While there are many kinds of solutions sold which are "guaranteed," the owner can make his own at less expense, even considering prices of alcohol and glycerin. The same treatment must be given to an acetylene gas producer, since the water will freeze in that and burst the tank.

Another thing which must be taken into account in winter is the warming of the mixture for starting so that it does not condense the moment it strikes the cold cylinder walls. Modern cars are provided with means for accomplishing this when the engine has started, but the hot-water jacket and hot-air furnace depend upon a warmed-up engine for their availability, and for starting other means must be devised. It may often be wise to drain off the anti-freeze solution from the cooling system and substitute hot water until the engine is well warmed up, then replacing the anti-freeze mixture. There also are various devices for heating the carburetor and intake manifold while the engine is warming up. There is an electric heater, where one has current in the garage and other ways of accomplishing the same thing. If no better means is at hand a hot-water bottle about half full, so that it can be wrapped about the manifold, may do it all right; or a cloth wrapped about the manifold and carburetor without covering the air intake, and a kettle of hot water, may do it satisfactorily. These methods are considered more at length in the preceding chapter.

It will doubtless be found necessary to prime the engine in starting in cold weather, and it is wise to carry a squirt can for this purpose, though a piece of waste saturated from the carburetor drip cock and squeezed over the priming cup will do the trick. If there are no priming cups it means taking out the spark plugs.

For running at low temperatures it will be found desirable, if indeed not necessary, to keep the anti-freeze solution from cooling too rapidly and thus retarding combustion in the cylinders. Most engines run better in the winter when the fan is disconnected by removing the belt. When it becomes very cold, however, other means must be provided in the way of radiator covers. These may be procured at any supply house, fitted to any car. They are in various forms, usually with a curtain which may be lifted for moderate temperatures and closed when extremes are reached. Anything which will cover the air spaces of the radiator may be used in an emergency, if one is caught by a sudden drop in the temperature. A blanket, a bag, even a newspaper or wrapping paper tied on will work properly until better provision can be made.

Care of the lubrication system is needed also in cold weather, since oil does not flow the same when cold as when warm. Most manufacturers give a schedule of oils for different seasons and this should be followed explicitly for best results. The owner should make sure that the oil is feeding through the system. If there is a dash sight feed it should be watched, for while oil does not freeze, it does get very viscid and, like molasses, flows stiff at low temperatures. However, winter lubrication has been studied by engineers for a quarter of a century and oils which are suited to all climes and all extremes are no novelty. The manufacturer is the best judge of the oil which will work most satisfactorily in the machine he turns out; besides, general advice could not be given which would apply to all cars. As a rule the man who sells oil should not be taken as an adviser in lubrication. In case of doubt go to the service station, if within reach, for advice.

This does not mean that an owner should not substitute a different brand of oil when he cannot get the one the manufacturer specifies; but he should get a corresponding quality and then watch results closely until a supply of the right kind is available. Experience and study will be a sufficient guide for the careful owner.

CHAPTER XXIX

OVERHEATING THE ENGINE IN SUMMER

THE automobile engine will heat up too quickly in hot weather, just as an individual will. No, we did not say overeat; though if you let the engine gorge itself too long on motor fodder, it will help to overheat as well as overeat. There are a variety of reasons for the overheating, which it is well for the novice to understand.

Those who have found it necessary during the winter to cover the radiator and take off the fan belt and do other things to keep the engine hot enough to run smoothly and with the proper vaporization and firing, may find in summer that they are having as much or more trouble in keeping the engine cool enough to run properly.

Generally speaking, the nearer to the boiling point we can run the engine without actually having the water boil and steam away, the more efficient it will be. Some engines, in fact, develop much less than the maximum horse-power because they are too well cooled, and yet we hear a great many complaints about the water boiling in the radiator and the engine overheating.

This would not occur if everything were working as the designer intended it should. During cold weather the man who drives with a retarded spark uses up more gasoline than necessary, but he is not bothered with overheating. When the mercury goes up he finds that his engine overheats and gives him trouble. He has not changed his manner of driving, and cannot understand why there should be trouble.

Driving the engine at high speed with the spark retarded is one very good way of overheating the engine. As a matter of fact, the battery ignition systems which are now coming more into use require considerable manipulation of the spark-control lever, and the tendency is, because the engine knocks at low speed, to leave the lever partly retarded, instead of advancing it, when a higher speed is reached.

With the magneto, it is the general practice to advance the lever to three-fourths or seven-eighths of the full range right after the engine is started and leave it there for practically all work, except very high speeds. This may be done largely with such a system, because the nature of the spark given by the magneto changes somewhat with the speed of the engine, and the equivalent of an automatic advance and retard of the spark occurs with the variation of speed of the motor. With the battery system, however, there is very little change in the nature of the spark effected by the engine speed.

A frequent cause of chronic overheating may be traced to sediment in the radiator which cuts off free radiation of the heat. This usually may be removed by the use of a saturated solution of washing soda and water. With the advent of summer each year it would be well to fill the cooling system with a solution of this sort and run the engine for several hours and then drain it off and refill the system with clean water. If in the system used a pump is employed, one should disconnect the upper hose from the radiator and run the engine to pump the solution out of the system. At the same time water from a hose or other source should be fed into the top of the radiator as fast as it is pumped out, and thus flush the entire system, before connecting up the hose again.

Where the thermo-syphon system is used, which does not employ a pump, this, of course, cannot be done, but one should remove both upper and lower hose connections after running the engine with the solution and wash it out with fresh water as well as possible. A hose inserted in the upper connection probably would force all the solution out with any collection of sediment, and the same process with the radiator ought to clean it out.

Fan belts are more likely to get out of order in hot weather than in cold weather; perhaps this is because the engine throws oil or grease more readily when it is warm. Belts should have grease enough to keep them soft and pliable, of course, but too much causes slipping. They should be wiped free of all oil occasionally. There is always a belt adjustment and this should be tightened so that there is sufficient tension to drive the fan at all engine speeds.

Some engines have the spokes of the fly-wheel shaped to form a fan, and where this is the case the oil pan and hood should be kept tight so that air will be drawn through the radiator rather than through other openings. If the radiator is not kept free from oil the outside passages will very quickly collect dust, which will prevent a free flow of air and cut off radiating surface, which also occurs when the front of the radiator is smeared too thickly with paint.

Pumps do wear out, but this is one of the last places to look for trouble. The action of the pump may be determined usually by removing the radiator filler cap when the engine is running and noting whether the water is circulating, but if a baffle plate is placed in the filler opening, it cannot be seen, and a test may be made in the same manner in which the cleaning solution is washed out, namely, by removing the top hose from the radiator and running the engine, while supplying water through the filler opening.

With the thermo-syphon system there is very little pressure generated and a slight obstruction will stop the flow of water. Therefore it is more necessary to keep the system free from sediment and to see that the gaskets at the joints are made with circular openings of the right sizes so as not to obstruct the flow of water. Likewise water must be kept above the top hose of the radiator in order to have any circulation in this type of cooling system.

Another cause of overheating, which it has been found very difficult to locate, comes from carelessness in stretching the hose over the pipe. In doing this sometimes the inner lining of the hose is loosened and folds back, covering the opening of the pipe, so that water does not flow freely. It looks all right from the outside, but an examination of the inside will show that it is almost entirely clogged at the end. Also, the lining of the hose will often loosen up and pieces will lodge where they cut off the circulation.

Keep the engine free from carbon and keep the valve push rods adjusted close, have the mixture as lean as possible and be sure the exhaust from the muffler is free. Taking care of these things and seeing that the other things mentioned are all right, will prevent most of the overheating which troubles the novice, if, indeed, not all of it.

They are things which should not be trusted entirely to chauffeur or garage man, but the owner should learn how to take care of them himself; then if he wants to hire it done he will know if it is being done according to his orders and will recognize the symptoms when anything goes wrong. It may take a little time and get one's hands somewhat soiled, but it pays in the long run, not alone in the saving of labor but in the absence of annoyance when out on a trip. It is far from pleasant to have to stop along a hot roadside to make repairs which should have been done in the garage, with probable delay and consequent upsetting of the schedule. Therefore, it behooves the owner to look after these things before starting out and to learn his car so well that he will anticipate troubles and by removing causes save time and money.

CHAPTER XXX

SOME OTHER HOT-WEATHER TIPS

THERE are a number of other points which should be borne in mind by auto owners with the coming of hot weather, if the most efficient service is to be had from the car.

One of the Y. M. C. A. secretaries excitedly called the school to ask why a seemingly good tire should blow out after a short run. A few minutes later another secretary put the same inquiry with variations. That is, he had a tire which was rather old, but it had been inflated for two weeks and had been running every day since inflation, when it tested eighty pounds' pressure. It had blown out.

The first secretary had been invited by a friend to take a ride. He had watched the tires inflated and all other bits of preparedness and saw that nothing was overlooked, and settled down for a fine ride. The blow-out came about five miles away.

The trouble with both was that they had not taken into account the fact that summer was at hand. Experienced drivers know that in hot weather, whether it is according to rules or not, it is better not to keep the tire pressure so high as during the cold months, even though it means more wear on the tires.

Considerable heat is generated by rolling a tire over the ground. This heat expands the air in the tire and increases the pressure. In the winter this heat is absorbed to a large extent by the cold atmosphere and the cold and wet pavements, and therefore the pressure does not vary so much. In the summer the roads are very hot, the air temperature is high, and the heat generated by friction is not carried off to any appreciable extent.

On a recent summer trip the writer noticed that the car was riding harder than usual and a test of the pressure on the tires developed the fact that it was above normal. To find out just what the difference in pressure would be, the pressure for each tire was taken before leaving the garage next morning. After rolling about forty miles at an average speed of thirty miles an hour, the pressure was again tested. It had increased about twelve pounds on each tire.

Several tire manufacturers insist that owners shall not carry less pressure on tires in hot weather, saying that the increased pressure due to heat is not sufficient to materially affect their make. This probably is true for new tires, or for about two-thirds of their guaranteed life, but if the tire has been weakened, through having been run under-inflated, or from fabric deterioration through cuts in the tread, there is danger from the increase in pressure due to heat.

More tires are damaged by under-inflation than by over-inflation, because the former breaks down the side walls through running flat, in practically every case, while the over-inflation causes a blow-out only when the tire is weak at some point. It would be good practice, however, on hot summer days, to leave the garage with the tire pressure about ten pounds less than that specified by the manufacturer as being correct for his make. Any driver ought to test out his tires after running at a good clip on a hot day and find out just what they do. A little persistence would enable him to understand how much his tires heat up and he could regulate the pressure accordingly.

Manufacturers of high-pressure tires resent the above advice and declare that it is wrong. The succeeding chapter tells of definite tests made and the owner can draw his own inferences and decide for himself whether he wants *high* tire mileage, or comfort with *pretty good* tire mileage.

There are some other hot-weather points which it might be well to keep in mind if one would get the best results from the car. One of these is the care of the carburetor. It will be found usually that not quite so much gasoline is required as in cold weather, and therefore the dash adjustment may be carried a little nearer the lean, or air, side. This not only saves gasoline, but increases the power of the motor, for a too heavy mixture makes it run logy.

It will be found also that in most cases the hot-air stove of the carburetor may be dispensed with or adjusted. Usually provision is made on the hot-air stoves for allowing some cold air to enter, or to take cold air entirely. Where the carburetor is water-jacketed, there usually is a valve that may be closed to prevent the flow of hot water. Experiment will determine whether it is advisable to cut out the heat entirely on the individual carburetor, since all are not benefited by the change.

The water in the storage battery will evaporate more quickly in hot weather and where it has been necessary to replenish it once in two weeks in the winter, it will need to be done every week in hot weather. This is not entirely due to evaporation from heat but is accounted for in part by the fact that the engine starts easier and therefore less current is used for starting; also there is more daylight and the lamps are used less. Therefore the battery is more often in a fully charged condition, and in this condition the charging current causes more gas than when the battery is lower. This is due to the chemical action which decomposes the water, the hydrogen and oxygen gases passing off through the vent holes; the water escapes from this cause as gas and not as vapor, as it does when there is evaporation.

In hot weather city streets are generally sprinkled regularly and the country roads are oiled some time during the season. The novice going behind a street sprinkler, or reaching an oiled stretch of road, should exercise particular care to prevent skidding, as he would be unlikely to realize the danger unless he has experienced it once. This is explained fully in the part of this book devoted to skidding.

Hot weather softens grease, so that trouble may be experienced through grease or oil seeping out of transmission or differential cases, or from the grease cups. Many manufacturers recommend a heavier grease for summer than for winter to give the greatest efficiency. This softening of the grease is likely to make a little ring of grease around each cup, which will collect dust and give the car an unkempt appearance, besides there is the possibility of some of the dust working into the bearing. Grease cups must be kept turned down so that the dust is forced out, and then it should be carefully wiped off.

Every bearing needs additional care to keep dust out and lubricant in, but every moment spent in this way pays dividends in expense saved and comfort and freedom from annoyance on the road, so that the owner will do well to take note that hot weather calls for added care and precautions.

CHAPTER XXXI

HOT-WEATHER TIRE EXPANSION

THERE is considerable question whether the pressure on tires should be decreased during the hot summer days. Tire manufacturers claim, as a rule, that tires heat more on low pressure than when run at the full pressure given by them. They claim that even a slight decrease to offset any increase from heating, because of warmer temperature of the air, friction, and the hot pavements, will injure the tires. On the other hand, drivers of long experience insist that the car should be started out with the tires softer than in cold weather. Still others insist that the tire pressure demanded by the manufacturer makes the tire too hard for comfort and that when the pressure is increased by heat it makes the tire as hard as one of solid rubber. There is some truth on both sides.

There has been considerable criticism of the conclusions drawn from the writer's experience with tires while on a summer tour, related in the previous chapter. He stated that there was a twelve-pound increase in a forty-mile run. This was disputed. Tests prove that he was right and that in city driving tires ordinarily heat up even when the conditions are not extreme.

To determine what effect the hot weather has on tires in the city, the author drove a 3200-pound Model L Locomobile, equipped all around with 34 × 4½ inch tires, through the park and on Riverside Drive for fifteen miles at ordinary city-traffic speed, which always is under twenty miles an hour. The thermometer registered 86 degrees and the day was partly overcast, so that the full effect of the sun on the pavements was not obtained. The tires were inflated to full 90 pounds, which is the pressure recommended by many manufacturers.

At the end of the run, one tire registered 101 pounds, two were 100 pounds, and one was 99 pounds. The conditions were not excessive in any way and the weather was not abnormal, the road was smooth except for very short stretches, the speed was low, and the tires were of ample size for the weight of car and load.

After the test run, a gauge was made to test the flattening effect on the tire from a lowered pressure. With the car loaded it was necessary to decrease the pressure in the tire to 65 pounds to have $\frac{1}{16}$ inch bulge of the side of the tire. At 70 pounds pressure there was no flattening perceptible by the use of the gauge.

It is certain that more tires are damaged by under-inflation than by over-inflation, also that perfect new tires will stand more than 20 pounds over-inflation without damage to them. But it is reasonable to believe that, if a tire has become weakened from any cause, it will blow out quicker under increased pressure. It is also a fact that a tire inflated to the pressure recommended by many manufacturers has very little resiliency, and the riding qualities of the car are very greatly impaired, and when the pressure rises slightly higher the tire loses its chief function, that of absorbing the small road shocks. Anyone who has had the experience of riding on hard tires knows the discomfort of it; one might about as well ride on solid tires.

But all this comes back to the question: What is under-inflation? A tire with ten pounds less pressure than recommended probably will heat more than when carrying a full pressure; but it will very quickly come up to the required pressure when the car is run.

As the pressure recommended by many manufacturers is the extreme so far as comfort in riding is concerned, the car owner must take his choice between comfort and tire mileage, assuming that a slightly less pressure does decrease the life of the tire. Presumably the average owner would rather have comfortable riding, even at the expense of tire mileage, and we are not prepared to admit that decreased mileage would be an inevitable result with ten pounds less pressure. Beyond question the average man would not use a substitute for gasoline which gave him all sorts of discomfort because it did not run the engine smoothly, even if it gave a slightly greater mileage to the gallon.

One manufacturer of fabric tires recommends 56 pounds pressure for a 4-inch tire and guarantees 5000 miles, and makes the claim that this pressure makes riding much more comfortable. Another well-known manufacturer advises inflating the tire only to the point where there is no bulge or flattening, and another type of pneumatic tire has become very popular because it requires still less pressure and makes riding that much more pleasurable.

Where tires are hard and roads are rough, the machine jumps around so that it is more likely to jump off the road, therefore there is an element of safety as well as comfort involved.

For all around comfort, though possibly with lessened tire mileage, the conclusion is reached that a ten-pound decrease in pressure in hot summer weather is desirable. The tire cannot be damaged much, because after a very few minutes on really hot pavements the pressure will equal that recommended by the most exacting manufacturer and any overheating due to this cause would be a matter of very short duration.

As was said in the previous chapter, the wise owner will test out his car and tires and find out just the proper amount of decrease the tires will stand. He will then have to decide whether he wants the highest amount of tire mileage or the highest amount of comfort and act accordingly.

It is beside the argument, but a matter of fact, that a certain tire salesman, a fellow who is quite insistent upon a certain pressure being maintained, makes it his invariable practice to deflate his tires ten pounds in hot weather; he wants tire mileage, too.

All of which goes to show that some people do not always practice what they preach, or take the medicine they give to others.

CHAPTER XXXII

GUARDING AGAINST FIRE

THE education of automobile owners and chauffeurs is decreasing the number of cars which go up in smoke, but there still are cases enough to require a word of warning as to causes and prevention. Automobile fires sometimes come from causes not ordinarily considered under the control of the driver. However, a little extra caution in a few matters will render the motorist practically free from danger.

Of course, the principal cause of automobile fires is from back-firing. Without going into all the causes of back-firing, the chief one is too lean a mixture fed to the cylinders. This will almost invariably cause back-fire in starting. Really, the chief trouble comes in starting when the engine is cold, and naturally this is most frequent in the winter. When there is a back-fire a sheet of flame comes from the air intake of the carburetor; if there is anything inflammable in that vicinity, it is quite likely to take fire.

Gasoline vaporizes so rapidly that if there is gasoline in the drip pan there is almost sure to be a sufficient mixture around the carburetor to make trouble. As a matter of fact, the drip pan under the carburetor should be so arranged as to allow any gasoline to be drained off before it has had time to vaporize. Indeed, there ought not to be very much gasoline in the drip pan at any time. If it comes from a leak in the supply pipe or the connection to the carburetor, the leak should be repaired. If it comes from an overflow of the carburetor due to poor seating of the float valve, that should be taken apart and cleaned so that the float valve will seat properly. These two things are practically the only occasion for gasoline in the drip pan.

Another cause of fire may be in running for some time at extreme speed. This usually will cause the exhaust pipe to become very hot, sometimes to glow. The exhaust pipe in some cases is placed close to the woodwork of the car, which may be set on fire. Particularly is this true if the woodwork has an accumulation of grease and oil, and here is where caution will have a beneficial effect. The owner who keeps the woodwork free from oil and grease—cleans it off regularly and thoroughly—minimizes the danger at this point.

The pipe also heats up when the engine is run with a greatly retarded spark. Sometimes the pipe gets red-hot and it is an easy matter to ignite the woodwork. Here again oil or grease would increase the danger. The economical operator will not allow grease and oil to be wasted in this way, aside from the fact that grease, oil, and gasoline in drip pan or carburetor form a menace hard to overestimate.

Fires have been started occasionally by opening the muffler "cut-out" in starting up. This is particularly dangerous when the car is in a garage, where usually there are grease and gasoline spilled around on the floor, giving off fumes and creating a danger zone. Occasionally when the car is standing in the garage the supply line will drip a little. It may be all right when the gasoline is flowing into the carburetor regularly, but when it stands, a tiny drip will make a considerable mixture under the car. A leak, so small as to be unnoticed ordinarily, when continued over night will cause enough mixture to be dangerous. If, to aid the engine, the operator opens up the "cut-out," there are quite likely to be some sparks flying out. Sparks and gas mixture are a very perilous combination and there is pretty sure to be a blazing car in a moment.

Sometimes in filling the gasoline tank it overflows and drips down. Perhaps the driver, delayed by taking on gasoline, is in a hurry, so he opens the "cut-out" and finds that making haste is often dangerous.

Another cause of fires comes from short-circuiting of the ignition or lighting systems when a storage battery is used. Occasionally a short-circuit will heat one of the wires red-hot and burn off the insulation. Then, if there be an accumulation of grease, oil, or gasoline, there will be trouble.

To obviate vibration, some chauffeurs pack around the battery with used waste, which is more or less greasy. It is possible for a tool to drop down on the battery and give off a spark, or, under vibration, a series of sparks, sufficient to set fire to the waste. It is on record, in one of the old-style cars, that a cushion spring wore through and dropped down on the battery, making a spark every time the spring touched the terminals, and eventually setting fire to the car. The remedy for all these instances is very obvious.

Another cause of fire, which has been written about a great deal, is static electricity, which is generated when gasoline is filtered through chamois under certain conditions. Very many funnels have a chamois strainer. Gasoline poured upon chamois creates static electricity. It is all right if the funnel touches the gas tank, but if it does not, a static spark is very likely to cross the gap and set fire to the volatilizing gasoline. The remedy, of course, is either not to use chamois or to see that there is a perfect connection between the funnel and the tank.

Since one of the chief troubles is the back-firing when the car is started, it would be well for the owner, when starting the car in cold weather, to enrich the mixture slightly; this will prevent the back-firing, and when the engine is well started the mixture may be adjusted to the proper proportion. Most cars now have a means of enriching the mixture on the dash.

It ought not to be necessary to suggest the wisdom of carrying along one of the approved fire extinguishers, but it is a fact that very many owners "take a chance." The insurance companies make a reduction in the premium when a fire extinguisher is carried, which is a pretty good indication that they consider it a valuable accessory on the car. Some companies insist that one be carried.

Inasmuch as fires may occur even with the most careful operator, from causes beyond his control, such as the accidental short-circuit, or the carelessness of others, it may be out of place to suggest that the owner of a valuable car, or one who really cares, insure his car. Rates are fairly reasonable, and if insurance ever is good it surely ought to be in the case of an automobile, where several thousands of dollars are often centered in a very small compass.

CHAPTER XXXIII

DON'T RUN AWAY FROM A FIRE

WHATEVER may be the cause of a fire in your automobile, do not run away from it. Stay and fight the fire. Often the utmost haste is needed in getting out of the car when a fire starts, but on the way out grab the fire extinguisher and turn to use it. Do not be afraid that there will be an explosion and run. There will be none, and if you work fast you may save serious damage to the car. Keep your head and fight.

The presumption is that you will have a good extinguisher on the car. Two would be better and more in keeping with a high-priced car, both placed where they can be gotten at instantly, for gasoline fires spread mighty fast. The causes of fires have been pretty well discussed in the preceding chapter, and the fact that care will prevent all but a negligible percentage of fires. Back-fire, for instance, may be made harmless by placing over the air intake a screen of wire gauze, such as is used in a miner's safety lamp. To prevent shutting off some of the air and deranging the carburetor, the screen should be much larger than the opening of the intake. It can be made in bulb shape and clamped, soldered, or wired in position, and it ought not to require more than average gumption to fit such a device on any carburetor. Make sure it is safety gauze.

There are several forms of gaskets advertised for this purpose, but all so far noticed were to go between the carburetor and intake and are too likely to cause condensation of the gasoline to be recommended for use. Particularly in cold weather would there be a likelihood of condensation of vaporized or partly vaporized gasoline. But with the wire-gauze screen above described the sting of back-fire will be gone, as no blaze could pass through it and so reach the gasoline fumes which might be in the drip pan.

One cause of fire not often mentioned because of its rarity, would be from sparks from the magneto or generator brushes, or from the breaker points which might be hot enough to ignite gasoline fumes and therefore are to be guarded against.

Since gasoline fumes are heavier than air usually the magneto and generator are set high enough to be above the danger point; and where the magneto is between the cylinders on the V-shaped installation, there would be no danger. On marine engines, however, high installation is being featured lately to offset this very danger.

If, after all precautions are taken, you are visited by fire, stay to fight it. Get only far enough away to escape being burned, and then fight and fight hard. Work the fire extinguisher for all it is worth, for in less time than it takes to read this page the fate of your car will have been decided.

Get out of your head, first of all, the idea that there is to be an explosion. It doesn't happen. The first puff from the burning gasoline is the nearest thing to an explosion you will see. After this first puff, it is fire, not explosion, you need fear and fight. Tanks will not explode unless empty of gasoline, or nearly so, and filled with gasoline fumes—that is, vapor and air mixed. Water is little good in fighting an automobile fire where gasoline and oil are burning.

There are several things, however, which will quench the flames, and which should be at hand. If you could get sand and salt in sufficient quantity on the flames it would be effectual, but of course one could hardly carry a sufficient quantity along. There are also tube extinguishers filled with a dry compound, which under favorable circumstances will do the trick. But the trouble is to get the compound at the seat of the fire, and to throw it violently upon the flame is impossible.

There is one thing, however, which will actually put out a gasoline fire, and it is such a safeguard that no owner can afford to be without it. That is the carbon tetra-chloride compound, which is the basis of all liquid extinguishers on the market. This, discharged close to the seat of the flames, forms a dense smoke-like gas which has no oxygen to feed the fire, which therefore goes out for lack of fuel. There are many good extinguishers on the market which use the carbon tetra-chloride mixture with other ingredients to keep it from corroding the pump, or to add some other quality to the compound. These extinguishers cost more than the dry compound tubes, but the man who can afford to own a car can afford to have the necessary appliances for its protection. One may never have occasion to use the fire extinguishers, but it is nice to know that they are ready if the emergency does come, for there isn't always a fire department handy, and if there is, generally the firemen arrive after the car is doomed.

CHAPTER XXXIV

DEATH IN THE GASOLINE

Most persons understand the danger of getting gasoline and fire in close proximity, but there is another peril in gasoline which is not so well comprehended—indeed has only come to the attention of scientists in recent months. It is death, called petromortis, or gasoline death, which lurks in the fumes of the burned gases from the exhaust pipe.

That which comes from the exhaust is no longer inflammable. It has served its purpose in the combustion chamber by burning with rapid expansion, furnishing power. It has undergone chemical changes, has been split up, the hydrocarbon uniting for the most part with the oxygen of the air in the mixture and forming carbon monoxide and carbon dioxide. The latter is carbonic acid gas, in which no living thing can live. The carbon monoxide is no less deadly, and besides there is the nitrogen from the air, which will suffocate as well, unless it mingles with the air freely.

These three gases exuding from the exhaust pipe into a confined space, such as a small garage, would quickly vitiate the atmosphere to a point where, close to the floor, asphyxiation would result, and sooner or later would fill the garage up to the point of the air intake. Then, as oxygen-filled air could not enter the intake to form mixture, the engine would slow down and stop.

There is little danger, since the deadly gases are heavier than air, when one is working about the garage in a standing posture, where the breathing apparatus would be above the strata of gases and taking in the normal air. But where one is working at the tires, or any part of the car below the level of the gases, or under the car, he might be overcome and die of suffocation in a few minutes.

It was not until such accidents really had occurred that the attention of the public was directed to this danger. Just recently a notable case of death from gasoline fumes was that of a popular actor. He was working in his garage, and because of the cold had the doors tightly closed. Getting under the car to adjust and oil the mechanism while the engine was running to warm it up, he was overcome by the gases which could not escape from the garage, and died before being discovered.

The chemical composition of the exhaust gases, according to an expert, is as follows:

	PER CENT.
Carbonic acid gas	8.70
Oxygen	2.75
Carbon monoxide	.30
Hydrocarbons	6.55
Nitrogen	81.70
	100.00

There is much disagreement as to the quantity of carbon monoxide necessary to be fatal. A well-known automobile trade journal recently said that 25 per cent. would produce death in half an hour and 15 per cent. would produce a violent headache in several hours. Other authorities claim that as little as .5 per cent. would be fatal. It is more probable that the large amount of suffocating gases, nitrogen and carbonic acid gas, produces unconsciousness, and then the carbon monoxide, attacking the blood particles, affects them so that they are unable to take in oxygen; hence death is certain.

There are several ways in which the danger may be obviated. The first and most natural one is to open the garage doors when the engine is being run, or have an opening on the level with the floor through which the heavy fumes may escape—roll out of the garage.

Another way is to provide a pipe, with flexible hose to attach it to the exhaust pipe and leading to the outer air, so that the exhaust would virtually be out-of-doors. This would not be expensive nor difficult for any ingenious man to arrange. The pipe should be larger than the exhaust nozzle and flexible metal hose of convenient length should be attached by the use of a reducer, the other end to be forced over the end of the exhaust, to which a short length of pipe might be added if necessary. Three or four inches would be long enough for the hose to attach easily. If necessary a clamp with wing nut on the bolt could be used to hold it in place.

Gasoline fumes which are not burned also have a peculiar effect when one inhales them profusely. Years ago when on a visit to Oil City, Pa., the writer was invited to inspect the old Imperial Refinery, one of the plants which helped found the Rockefeller millions. One phase of refining kerosene is to wash out the volatile elements which make it dangerous. This is done in an agitator, where streams of water literally wash the kerosene, keeping it eddying and boiling as though a fire were under it. The top is open and around it runs a gallery from which the process is watched. It was a favorite trick of the employes to conduct a stranger to this gallery and steer him to the lee side where he gets the full effect of the fumes which pass off. Most men not used to it began to feel light-headed in a few minutes and to act as though they had been imbibing strong waters. It is an exact simile of the alcoholic condition, though without the after effects the next day. To a limited degree one may acquire the same effects from gasoline in the garage if there are large open gasoline receptacles to send off fumes sufficient to affect one. Of course, if there were enough to do this, a spark from any source would start a fire.

CHAPTER XXXV

SHIFTING GEARS ON HILLS

ONE of the most humiliating experiences which can come to an owner is to have to ask his guests, even if it be only friend wife, to get out and walk when a long and steep hill is partly ascended. While there are conditions of engine which would make hill climbing hard, if not impossible, they are due to neglect or poor adjustment, so that the engine has not power enough to negotiate stiff grades. The owner who keeps the motor in proper condition, in practically any make of car on the market today, should have no trouble in making the worst hills. Yet how often we find cars stalled on mountain roads and even on steep city streets, and see owner and guests walking or pushing the car.

Recently the writer, going from Greenwood Lake to Tuxedo, in Orange County, New York, in a well-known make of touring car, passed six cars of different kinds stalled at the very start of the climb over Sterling Mountain. The first one met was a Ford. Now there is no reason whatever for stalling a car of this make on any hill. It is a matter of comment that the Ford—much despised by the owner of the big car—will take hills that some multi-cylindered and high-powered cars make much fuss over, and do it handily. The trouble was that the driver started at high speed and then did not know how to shift the gears properly and the car stalled.

When we reached it the Ford was stalled across the roadway and we had to stop until the driver started the engine and backed the car to one side. Not being familiar with the hill-climbing abilities of the car in which he was seated, the writer inquired of our driver if it were not better to walk awhile.

"No one will ever walk while I am driving," was the reply, "unless something breaks. I do not go out riding to walk; besides the car will carry us all right."

And it did. Although we had stopped at the very foot of a steep grade fifty feet long, the car on low gear took it without a stutter, and then coming to a lesser grade, a shift was made to second gear. We did not use first speed more than once or twice, and then only to keep from stalling on the grade when it was necessary to slow down in passing other cars at narrow points in the road. Occasionally high speed was possible for short stretches. When well over the top of the mountain we stopped to let the engine cool off for probably ten minutes and then coasted nearly all the way down the mountain side.

There was no need of any of the cars stalling on this grade, though it is long and has many very steep places; there was no sign that any of the cars was deficient in power. The deficiency was in knowledge on the part of the drivers.

Where the driver understands gear shifting well enough to do it on a grade, the proper way to approach a hill is on high, with the accelerator opened enough, and spark advanced, to speed up the car. Then when the car begins to lose speed and before it has slowed down too much, the shift should be made to second-speed gear, which should carry the car up any ordinary hill. If an extra steep gradient be encountered, first speed may be necessary for that stretch.

It is well just as the foot of a hill is reached to open the throttle wide. If the engine begins to knock or otherwise labor, retard the spark enough to overcome this. In the chapter on "Driving the Car," detailed instructions for the operation of the gears in hill climbing and descending are given. Study these rules closely and try out your car on short grades before attempting long and steep hills. Make sure that you know how to operate the levers for gear shifting and then take things easy. Do not be in a hurry. Haste makes waste.

While many high-powered cars, and sometimes those of less pretentious build, will take almost any hill on high gear, it is not always policy to do this. Some modern motors are designed with a view to make the climbing of hills easy, but even so, the climb made on second-speed gear will take but a trifle longer and the car will not be submitted to the tremendous strain of operation on high speed. It is all very well to boast that one's car will "take the worst hill on high," but a better boast would be that the car has stood up for two or three years longer than ordinary, and care in the operation will produce that result.

The driver whose engine is not in the best of condition and which is not delivering its full power, and especially if he is not fully versed in shifting the gears, would better not try to take a hill of any length or of any considerable grade on high. Indeed it is wise to shift into second gear before starting up the grade, for nothing is more unpleasant than stalling the engine half way up. And he ought not to despise low speed if necessary to negotiate the hill without straining the engine unduly. Motoring is not just piling up mileage records or speeding across the country as though the devil were at one's heels. There are a few things more desirable than miles per hour, even though the American "Get There" spirit be abroad. Generally speaking there is a direct relation between cost per mile and miles per hour, and while some owners may be able to afford twenty cents and upwards per mile, the average owner does not care to indulge regularly in such a cost figure.

When it comes to descending steep hills, the cost does not figure so much as safety. How often one sees cars tearing down a hill with the engine running, gear in high speed, and devil-may-care at the wheel. If the drivers realized the slight things upon which their fate hangs at such a time there would be more care. Ninety per cent. of all the accidents to automobiles are the result of sheer carelessness of the drivers; nine per cent. are from the carelessness of some other driver; only about one per cent. can be set down to breaks of parts, blow-outs, or other things not to be prevented by ordinary precautions.

On a slight and straight hill it is all right to go down on high speed, simply shutting off the ignition so that the engine will act as a brake, the foot brake being used if necessary; but on a steep hill it is far wiser to shift into second-speed or even first-speed gear before attempting to descend. The engine will exert a powerful braking force in low-speed gear. Besides, the running and emergency brakes are to be used alternately, so that on a long hill the brake linings will not be burned up. Of course the clutch must be left engaged to secure the braking effect of the engine.

It is a mighty bad thing to start down a hill in high gear and then, half way down, find that brakes will not hold, or that something has gone wrong suddenly. Long and steep hills rarely are wide or smooth; there are ditches and humps and rocks, sometimes, and narrow places where there is scarce room for two cars to pass, and less than perfect control of the car is perilous. "Better be safe than sorry" is a homely old saw, but it is pertinent.

Another thing is that the hill speedster is one of the greatest menaces to other drivers so far found. If one cares not for his own car or neck, at least he should have a care for the others on the hill; and whether it is on the ascent or descent the speedster endangers every one else going in either direction at the same time, except perhaps the fellow who is following him at a safe pace. It is no comfort to know that the mortality is highest among the speed fiends of motordom; occasionally they raise the mortality figure of the drivers who practice safety first.

CHAPTER XXXVI

KEEPING THE CAR SLEEK

Of course, if one does not care for appearances, and has no pride in the bright and shiny varnish of the body and in the absence of rustiness of the top, and thinks because the engine is under the hood no one will see that it has been neglected, this section will not particularly interest the reader. But, on the other hand, if these things count, and the owner understands that true economy consists in keeping not only the running parts in condition, but everything else at the top notch of perfection, then he will heed the advice herein.

Just because it does not show to the passer-by, many think that the appearance of the engine does not count; that it is not essential that it be kept free of oil, grease, dust, and corrosion of iron and brass. Get this idea out of the head instanter. It is false and has much to do with breakdown and wear-out of the motor. The cleaner it is kept the longer will it run satisfactorily, both as to troubles and to length of life. One may well err on the side of cleanliness rather than be somewhat slovenly. The motor ought to be cleaned off on the outside after any lengthy trip, or after any run when roads are dusty, or oily, or sandy.

One may be as particular as possible, yet there will be some oil or grease on the motor exterior. Probably that which lodges upon the cylinders will, if there is much hill climbing to heat the motor unduly, make itself visible and smellable—visible in a thin streak of smoke coming from the hood, and smellable to the point of offensiveness when that streak of smoke strikes the olfactory nerves. But in most instances it will remain upon the engine, gradually becoming a gum from the drying up of the substance and the accretion of dust from the road. The longer it remains the harder it is to remove it; hence when the work is done in the garage every time the car comes in, it will take but a few minutes and slight labor; while if allowed to accumulate, it may mean hours' work to get rid of the hard deposit.

Sufficient instruction has been given as to the care of the working parts of the motor, so that only the exterior need be considered at this time. Begin at the top. First of all see that the wire terminals at the spark plugs are free from corrosion and grease. They should be dry and clean if they are to transmit the current to the plugs. Usually the wires are carried in a tube to protect them from heat and grease, but not always. In any event, trace along the wires to see that oil or grease is not present upon them. Either will rot the rubber insulation and cause a leak which will affect the ignition. Examine all the terminals under the hood for the same purpose, and every once in a while disconnect the wires one by one and scrape the terminals bright, also the contact point where terminal is fastened. Replace the wires one by one as you clean them so they will not become disarranged. See also that there is no oil, grease, or dirt on the spark plugs, for it might form a sufficient path for current to practically short-circuit the plug.

Wipe off the top of the cylinders and blow out accumulations of dust from any recesses where it has collected. If there is thickened or gummy oil upon the metal, which will not wipe off readily, saturate the waste or cloth in gasoline at the carburetor drip cock, and it will loosen up quickly. Gasoline is more convenient, but kerosene will do the work better, leaving a surface less likely to rust. In the same way clean the exterior of all the parts of the motor and everything attached to it. Where the brass shows corrosion, use a cleaning compound to remove it. Brass may be kept from corroding in wet weather by coating it with whiting. Several good compounds also are sold for this purpose. Bright iron parts may be kept from rusting by wiping them with a rag dampened with a thin oil, which should be wiped off regularly, and there never should be enough to show.

The fan, fan belt, pulleys, gear casings, and other parts at the front end collect much dust and should be kept clean. The air holes through the radiator, also, must be kept free of dust, oil, and asphalt from oiled roads. In fact every part under the hood needs frequent cleaning.

There are some parts of the chassis and undergear which will not be readily reached by the hose and water when cleaning the body; therefore they should first be rubbed off and cleaned of dirt, grease, and accumulations of asphalt from oiled roads, or mud. Do this while the space under the car is dry, and if it is done regularly it will not be difficult to keep this part of the car in order. The parts of the various rods and rocker shafts, and particularly near the bearings, should be kept clean.

If one will make a "creeper" from which to work when getting under the car, it will remove most of the objections which drivers have to "getting under." Take a board of twelve inches wide and five feet long and mount casters which move freely under it. At one end place an inclined head or shoulder rest a foot long and with four or five inches' rise. Then cover the upper side with carpet, padded to make it comfortable. Lying down upon this, one may move about under the car in ease and get at all the mechanism readily. It is not only good for cleaning time, but when inspecting or oiling, or tightening up the bolts and nuts and bearings which may be reached only from beneath the car. It also keeps one off a wet floor or ground.

Next take a hose, if one be available, and play it freely all over the body and running gear, fenders, mud guards, wheels, with care, of course, that the upholstery be not sprinkled too much. Do a thorough job with the hose but do not use a powerful stream upon the highly polished surfaces. It will not only take off dust but loosen up mud, and the force of the spray will take off fresh accumulations of asphalt from mud guards and chassis. Then with the hose playing ahead, use a soft sponge to go over all the parts to remove any remaining dirt and rinse down with water alone. Next, with cloth and chamois dry the woodwork and other painted surfaces until they shine.

Where mud and asphalt are dried and refractory, other means must be taken to remove them before rinsing and drying. Mud may be softened by holding a saturated sponge over it for a few moments. If the mud be mixed with oil or grease so that water does not soften it, kerosene will, and it does not take much of it. Kerosene also will soften the asphalt which clings to the car. Grease and oil also yield to kerosene, which should be wiped off and the painted parts polished with a cloth dampened with linseed oil. Naturally this should be wiped off completely so that it would not become a dust catcher.

Do not use soap on the highly polished surfaces of the body. Most soaps have free alkali—lye—in their composition, and while this makes them cut dirt and grease fast, it injures the varnished surface, in a short time wearing off the gloss. Washing is the better done when the hose only is used. In the country, where a hose is not available, the washing will be slower, since the water in a pail must be renewed frequently and the sponge rinsed practically every stroke to rid it of grit. Where it is possible to run a line from tank to the garage, or, if there is no tank, from an elevated barrel, which can be filled with a force pump, it should be done.

There are various preparations sold for renewing the surface of auto bodies after it begins to dull. Good gloss should last a year with care, especially if it be wiped over occasionally with a soft cloth dampened with a mixture of linseed oil and a little high-grade carriage varnish—a half pint to the gallon of oil. As there is a wide variation in both ingredients, if the mixture seems sticky when rubbed between the fingers or when applied to the car surface, add considerably more oil, as it is not intended as a new covering for the paint, but to freshen up the varnish.

Mohair tops need to be dusted with a moist sponge, using also soapsuds if spotted with oil or grease. Leather and its imitations may be kept in good condition if oiled occasionally or treated with one of the good preparations sold. The top should be dried before folding down. After driving through a shower let the top stay up until sun and wind have dried it thoroughly. Care in folding will lengthen the life of the top. Freedom from cracks and creases will mean a dry top, to insure which is worth any amount of trouble.

Keeping the car covered when in the garage pays, for dust will blow in and settle over all parts. The upholstery also may be protected by slip covers, which should be kept on during dusty trips, and be washed when dirty. Leather cushions should be freshened the same as the top.

The man who has cared for a fine carriage will know what to do with similar parts of the automobile; others should learn how to care for them, and understand that varnished and polished surfaces will become dulled if the car is stored in a stable, or adjacent to stable or barnyard. If a barn is converted into a garage, it should be thoroughly renovated and fitted with a cement floor sloping to the center, with a drain leading outside, so that the car may be washed there and the water run off through the drain.

In fact the owner of a car may find something to do all the time for convenience and comfort. If he arranges things conveniently he will not only save time but will be able to do better work, and will have the satisfaction of knowing that he is keeping down expense and getting the most out of his machine for the expenditure.

CHAPTER XXXVII

SOME THINGS A TOURIST SHOULD KNOW

THESE are the days of the tour and to thousands more each year it means a trip by automobile to lake or mountain, or the more pretentious visit to the old home, or to some new, and to the tourist, undiscovered, country. The tourist who goes by auto fully prepared for the emergencies which may arise, unhampered by railway schedule, and who will take time to enjoy himself, will get untold pleasure out of the trip.

The speedster knows nothing of the pleasure of touring, and the fellow who is always worrying lest he shall not make Squedunk Corners in time to eat and get to Possum Crossing for the night will be watching the road map and the clock on the dash so closely that the beauties nature has lavishly scattered about will be lost upon him, and his memory of the trip will be a procession of eating and sleeping houses, with trouble between them all.

The man who is starting out for the tour with a new car, which has been tried out enough to be sure that it is in condition, need only know that he has with him the things most likely to be needed for an emergency, but if the car has been in service for several months or more, he ought to give it a "once over" at least before starting.

One of the things to attend to is refilling the gear cases. Both the transmission and differential cases should be drained of all oil and washed out carefully with kerosene. At the same time the gears should be examined closely to see if they are in good shape. One may find one or two teeth chipped, though not broken enough to make the condition known by sound. It probably was too hard originally and the break is not the fault of the driver, but it should be replaced, for it is likely to give trouble at any time. When cleaned, the cases should be refilled with the proper amount of new lubricant, but not too much, because then it will work out and scatter over the car and probably get on the brake drums and make them slip.

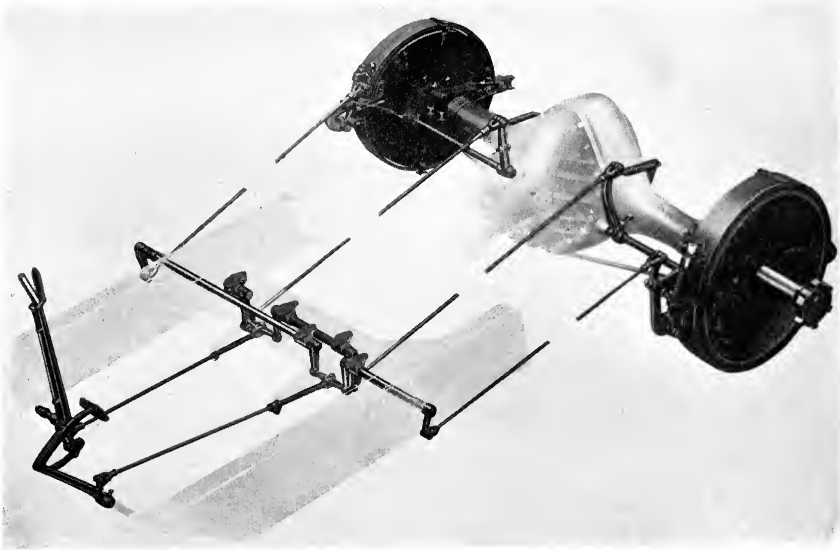
The crank case of the engine should be drained and cleaned out with kerosene and fresh oil be put in. If the oiling system is working properly, it is best to let it alone and see that it is kept filled with the proper quality of lubricant while on the road.

Of course the grease cups should be filled and all points which are lubricated by oil from a squirt can should be taken care of. The wheel bearings all should be examined to determine their condition and to see that they are properly lubricated. If very dirty they should be cleaned and fresh grease be applied.

It is well to carry an extra gallon of engine oil in the car, also a small can of grease. Garages are plenty, but sometimes an accident occurs which causes a loss of the main supply of oil and makes it impossible to drive even a mile without an extra supply. Likewise if the gasoline tank is not provided with an emergency tank or chamber, an extra gallon of gasoline should be carried. Convenient emergency tanks for this purpose may be purchased at any accessory store.

Both sets of brakes should be carefully examined to see that the lining is not worn too thin and that the different pins and clevises of the brake linkage are not worn so as to be weak and likely to give away in touring under extraordinary pressure. Often in touring one comes upon unexpected grades, some of them miles long, and the tourist should be prepared for prolonged and extraordinary service.

Where prolonged service is required it should be



BRAKE LEVERS AND LINKAGE, SHOWING EQUALIZING ROD AND SPRINGS

possible to use the two sets of brakes alternately. In this connection it is well to keep in mind that on long grades considerable braking may be done by cutting off the ignition and allowing the car to turn the engine over in high or intermediate gear. Keeping the car down to a rather low speed in this manner will also be found to save burning up the brake linings.

It is of the utmost necessity to keep the brake drums free from oil. When the car is driven out into the country the crown of the road tilts the car over, so that if there is too much oil in the differential case it will work through the axle housing to the brake drum on the right side. Of course this is taken care of largely as previously advised, by winding felt around the axle, or by not having too much lubricant in the differential, although enough is very necessary.

If the engine shows any tendency to knock on the hill it would be well to have the carbon removed before starting. It is very disagreeable to have to take a hill on second speed that could be taken on high if the throttle could be kept open without causing knocking. Trips may be practically spoiled by the fact that the engine is full of carbon and does not have sufficient power to negotiate the hills.

Of course the car should be gone over systematically to see that all nuts are tight and properly supplied with cotter pins or lock washers. All parts should be scrutinized carefully to see that there are no cracked or badly worn parts likely to give out under the severe strain of touring.

The compression of the engine should be tested and if found weak in any cylinder the valves should be ground in. Spark plugs should be made perfectly clean, magneto interrupter points cleaned and adjusted to gauge and high-tension distributor cleaned out, and the battery should be tested to make sure it is in normal condition. If almost discharged, a charge should be given it from some external source. The commutators of the generator and starting motor should be examined and if badly scored they will need to be trued up. If the storage battery is depended upon entirely for ignition, a set of dry cells should be carried so that in case of entire failure of the storage battery, ignition and lights may be had for a short time, even though the engine has to be cranked by hand.

Some annoyance may be saved by examining the springs to see if there is a cracked leaf to be replaced. Spring repair attachments are sold, but it depends upon the ingenuity of the individual whether repairs of this sort can be made upon the road.

In addition to tools and the other things previously recommended to be carried, the tourist should take at least one set of electric bulbs for the car. Spark plugs may be cleaned with very little trouble, but it is handier to carry two or three extra ones for quick exchange, cleaning the ones removed at the end of the day, or at the noon stop. One or two extra tires carried inflated and on the rims are usual, and it is wise to have two or three extra inner tubes. If one does have tire trouble it seems to come in bunches and it is just as well to be prepared for the worst. The tourist who is traveling very far from garages should carry also patches and cement.

Of course each car will carry a real fire extinguisher and a tow rope. If you do not need to be towed out of a mud hole yourself someone else will. Be prepared. Most drivers like to have along a spool of annealed wire, a pair of side-cutting pliers, and a roll of tire tape. It is really wonderful what an ingenious man can do with these things. The tools to be carried should be sufficient to do ordinary road repairs and the outfit suggested in a previous chapter is recommended.

As previously stated, it is not the man who rushes around and plans maximum distances for each day's run who gets the most out of the tour; he makes work out of pleasure keeping up with a schedule. It is better to allow more time for the runs, and then if one gets ahead of schedule to lay off a half day and see the sights and keep the car in condition.

CHAPTER XXXVIII

LITTLE KNOCKS ARE HARDLY BOOSTS

One of the worst things with which the autoist has to contend mechanically is the accumulation of carbon in the cylinders, clogging the piston rings, filling and short-circuiting the spark plugs and causing a knock which is not only annoying, but productive of trouble sooner or later. There are various reasons for the accumulation of carbon, such as poor gas, defective ignition, insufficient pressure, but few have assigned as a cause of carbon trouble and knocking a too high cylinder compression.

Too high compression occasions much of the knock ordinarily assigned to other causes. Engines are designed with a certain size combustion chamber, and with a chamber of that size to get a certain compression in pounds per square inch. The nearer we get to the point of pre-ignition without actually reaching pre-ignition, the more efficiently will the engine operate. Pre-ignition, of course, would make a knock.

A good many manufacturers make the compression figure just as high as they dare, with the result that, when the carbon forms, the size of the combustion chamber is reduced and the pressure is raised to such a degree that it will cause pre-ignition and its resultant knock. When a manufacturer tells the buyer that his engine is proof against carbon and the knocking occasioned thereby, he probably is trying to offset more serious "knocks" the car is receiving from disgruntled users.

This is an instance which illustrates the point:

A friend of mine has a four-cylinder engine in one of the later models of a well-known car of high speed and power. On several occasions we have been driving in and near the city and, after about 125 miles, we seemed always to have trouble with knocking in climbing hills. On one trip my friend had the carbon burned out carefully before starting. About the time we reached the end of the trip the engine began to knock on the hills from the collection of carbon. On our return he had the carbon burned out again and the knock ceased.

I advised him to raise the cylinders one-fourth of an inch by a fiber gasket under each cylinder casting, thus increasing the size of the combustion chamber and naturally lessening the compression. He also had to adjust the water connection and raise the valve push rods, and a few things of that sort. He ran the car upwards of 2000 miles after that before it began to show any signs of knocking under severe conditions, indicating that the cylinders needed to have the carbon removed.

Where the knock is caused in this way by a slight compression increase, it indicates that the manufacturer has put the pressure as high as the engine will stand, and the only way to cure it is by raising the cylinders or lowering the pistons. The gasket is the simpler method.

This trouble was very obvious in one model of car used for road instruction at the Automobile School. No amount of ordinary adjustment and cleaning out of the carbon would keep the car from knocking after very short service. It was taken to the service station several times and returned with the remark that it would "be all right now." It was not all right. Finally the request was made to let the car remain at the station several days and the experts would see what could be done. When it was returned the trouble was cured. But when the expert was asked what had been done he replied: "Nothing much." He admitted cleaning out the carbon and adjusting the carburetor. But a still hunt was made for the corrective cause and it was discovered that fiber gaskets had been put under the cylinders. They were camouflaged with enamel to conceal their presence, their existence was denied, and they were like the man without a country, "unhonored and unsung," but they did the trick, and until the car was retired because of old age and decrepitude the gaskets stood between the engine and the knock. Perhaps if that agent picks up this volume one day he will be surprised to find that his subterfuge was discovered. It may have been his little secret.

The owner who learns this remedy for knocking due to carbon and high compression will be saved a lot of worry and be enabled to cure the engine's ills, or have it done at the shop. But take it from the writer that carbon accumulation will cause any of the high compression engines to knock, and the only way to cure it is to lessen the compression or continually clean out carbon. Also the only simple way to lower the compression is to raise the cylinder with a fiber gasket.

CHAPTER XXXIX

SOME OTHER CAUSES OF KNOCKING

The motorist must not imagine that all knocks come from too great compression, however, for there are "fifty-seven other varieties" of knock to be taken into consideration. He must not take it for granted that the cylinders are filling up with carbon if the engine starts knocking while out on the road, nor is it a foregone conclusion that the main bearings are loose.

The knock may be from a totally different source. In fact there are so many different kinds of knocks that even an expert cannot always tell just where one comes from without totally disassembling the engine. Even then it sometimes puzzles him a lot by its elusiveness.

Most engines have a knock of some sort which annoys the driver, which might vary from a barely perceptible click to a blow that may be heard by persons standing on the sidewalk. A great many of the knocks do not do any harm;

that is, they are not causing any damage to the engine parts; but there are some knocks which require immediate attention to prevent the demolition of the engine or seriously damaging it. Some of these are loose connecting-rod bearing; cylinder loose on its base; lack of lubrication and consequent overheating; and a broken revolving or reciprocating member, which might tear things up if allowed to run. The spark advanced too far puts an excessive strain on the crank shaft, and a short circuit in the ignition does the same.

On the other hand there is no immediate danger if there is a piston slap, though pretty noisy; nor is there when the oil pump gives a thump or loud click at the valve seating. But on general principles when there is a knock its cause should be ascertained at once and expert advice be obtained as to whether it is dangerous. If so, it must be fixed before running further. If it is only a minor knock the repair can be left to a more convenient time.

So many of the knocks are only a matter of annoyance; that is, they do no more harm than to cause the driver unnecessary nerve jars and to spoil the pleasure of riding. But he will bother the various garage men and everybody else he can get to listen and then will not accept the assurance that the knock is not doing the car any harm.

As a matter of fact there are knocks peculiar to certain makes of engines that the manufacturers have not seen fit to eliminate because they are not harmful. Among these is the so-called "gas knock." Now the writers do not know what a "gas knock" is, and doubt if anybody else does. But it is a common term for the kind of a knock which cannot be located anywhere and it is laid to some action of the gas.

Sometimes the knocks are hard to locate. One of the school cars needed a new cam-shaft gear to replace a worn one which produced a knock. It was put on, but when the engine was started it was found that there was a worse knock than before. It took a long time to find that it was the new gear. It fitted very tight on the shaft and had to be forced on. Without being noticeable the forcing had cracked the hub, the crack extending through the rim, so that two of the teeth were out of true and had spread enough to pound when that portion of the gear came into mesh.

Another knock difficult to locate is caused by sticking exhaust valves. One of the valve stems has been oiled, say, and this has been allowed to burn to a nice sticky paste. Now, when the push rod opens the valve and starts down the valve does not follow closely. The spring brings it down, of course, but more slowly than it should, because of the sticky stem, and when the stem and push rod meet there is a thump.

It is ordinarily said that a lean mixture or an over advanced spark will cause knocking. As a matter of fact they do not do anything of the kind; but it is true that these things bring to our notice other faults, such as a worn piston or cylinder wall and consequent side slap, or they magnify some other worn part so that it becomes audible. As a matter of fact it is possible to advance the spark so far that it will try to reverse the engine and not have a particle of knock. And it is possible to have a mixture so lean that it will hardly run the engine yet have no knock; but if there is something else wrong it will bring that out.

Some of the causes of knocking discovered at the school have been collated and are given for the instruction of the novice:

Mechanical Looseness, Due to Improper Adjustment, or Wear:

Loose connecting-rod bearing, crank-pin end.
Crank-pin bearing out of round.
Main bearings of crank shaft loose.

Bearings too tight.

Wrist pin loose in piston.

Wrist pin loose in upper end of connecting rod.

Wrist pin not in line with crank shaft, causing side slap.

Piston ring loose in slot or broken.

Cam follower guide worn.

Cam loose on shaft.

Worm cams (Flat spot).

Fly-wheel loose on crank shaft (old models with keyed-on wheel).

Fly-wheel out of balance.

Worn or broken timing-gear teeth.

Cylinder loose at its base.

Timing gears loose on shaft.

Engine loose from frame.

Piston too small for cylinder, causing side slap.

Poor push-rod adjustment—gap too great.

Exhaust or inlet valve sticking in guide.

Spark plug touching valve.

Magneto coupling loose.

Fan-belt coupling striking pulley.

Fan blades striking something.

Worn cylinder, causing side slap.

Bent crank shaft.

Faulty Ignition:

Spark advanced too far.

Spark too late, causing overheating.

Short circuits in ignition system causing irregular spark.

Spark-plug points constructed wrong, causing them to overheat.

Spark plug in poor position.
Wrong timing of ignition system; too early, too late, or wrong order.
Dirty distributor, misdirecting the current.

Faulty Carburetion:

Pre-ignition, due to excessive carbon deposits.
Rich mixture, causing overheating.
Lean mixture, in conjunction with worn parts.

Faulty Lubrication:

Lack of oil.
Lubricants of poor quality.
Excess of oil causing carbon deposit.

Overheating of Engine:

Fan not working.
Pump parts not revolving.
Radiator clogged.
Pipe lines clogged.
Rubber hose defective inside, blocking flow of water.
Ignition timed too late.

Faulty Compression:

Engine designed with too high compression, causing pre-ignition when throttle is wide open.

There are, of course, many other causes which contribute to the little noises which accompany the car along the road, but the novice will find here the most common ones, and by a process of elimination may arrive at his particular bane; to find it naturally suggests the cure. Therefore, stop that knocking.

CHAPTER XL

CHASSIS KNOCKS

DOES your car chatter? Does it talk to you and protest against running over holes and bumps in the road? If it does, it is a sign to which you should pay attention, a hint that you should do away with the knocks and clicks and chattering which annoy you and everybody else within hearing as you run along. That is, if you can find them, for there are some noises so obscure as to defy detection even by the expert.

Such was the car which developed a sharp click whenever it was started forward or backward. It ran quite a long time before it was possible to discover just what and where it was. It was somewhere in the back, but so hidden as to defy detection. The rear axle was of the floating type, the construction in which the driving shaft is connected to the hub of the wheel by a number of flutings on the shaft, into which corresponding projections of the flange fitted. These had become worn and allowed sufficient play to cause a noise.

By walking alongside of the rear wheel while the car was being started and stopped, it was decided that the sound came from the hub of the wheel. The hub cap was removed and by placing the finger on the hub flange and end of shaft at the same time the play was detected by the sense of feeling, though it was hardly visible to the eye. The trouble was overcome by having the shaft welded to the flange.

A few days later the owner happened to be at the agency and told what he had found.

"So glad you came," was the response, "for we have been looking for the same kind of a click a long time ourselves and the service-station mechanics have not been able to locate it. They thought it was in the brake, but upon examination could see no reason for a click.

There have been cases where the wheel was keyed on, and where the keys had acquired sufficient play to cause a continuous knocking, especially when the machine was being driven at low speed. This sort of knocking is more likely to occur with the four-cylinder, slow-speed engine than with the high-speed, many-cylindered type.

A mysterious knock may sometimes be traced to the torque rod, when it becomes loose at the forward end, or to worn torque-tube bearings, and in some cases the bolts fastening the torque rods to the rear axle become loosened, or worn, causing a knock, especially when going over bumps or dropping into holes.

The brake rods become worn and set up a continuous clattering on rough roads and this noise is accentuated if the tires are kept inflated at too high a pressure. As a matter of fact the car owner has the choice between the greatest life for his tires and accompanying rattles and discomforts, and riding at a sufficiently low pressure to subdue these noises and make life in a car worth living; of course there will be an attendant higher wear of tires. Where the wear cannot be taken up by adjustments or using new bolts or pins, often the rattle may be ended by wiring a spiral spring to the frame and rattling part. This keeps it taut.

Worn spring-shackle bolts will not ordinarily cause knocking or rattling, but when going over bumps or holes the rebound of the body is sufficient to make the looseness audible. It can be overcome by having a new bolt put in, and prevented by keeping the bolts well lubricated.

Worn steering-knuckle pins and tie-rod bolts will sometimes be found responsible for knocks and rattles in the front end of the car. The remedy is obvious and the location of the noise is not so hard to find.

In addition to these we have rattles due to tools being thrown loosely into the tool box, and sometimes from the body bolts having become loosened. The lamps occasionally jolt loose and the license-plate bracket is sometimes so loose that it is audible as well as visible.

There are other knocks due to broken gear teeth and other broken parts, and sometimes these broken teeth, loose nuts, bolts, or pins in gear or differential case become wedged between the gear teeth and cause a knocking that is not hard to locate, albeit rather expensive to repair.

And then there are the knocks and rattles from the hundred or more accessories which are attached to the chassis of many cars and which sooner or later develop defects and noise.

The up-to-date, well-designed car in perfect shape is practically noiseless, and if a knock or rattle develops it indicates that something is worn or out of adjustment, and needs attention. The owner who takes care to have all parts properly lubricated and kept tight need fear none of these annoyances, and proper attention means lack of annoyance when out touring, while slovenly habits will advertise themselves to everyone along the road.

CHAPTER XLI

KEEPING DOWN THE AUTO UPKEEP

If the general run of auto owners and chauffeurs do not mend their ways city streets will be paved with a mixture of asphalt and auto parts and country roads will be lucrative fields for the junkman. Anyone who doubts this need but inspect the pavement at busy corners and see what a collection of junk is strewn along, particularly at the places where many cars make sudden stops.

To illustrate: The other day a car stopped and the driver pondered what was the matter that the engine had no power. Failing to get a solution, as he was near a garage, he called for a mechanic to look it over.

"A few minutes ago," he said, "the engine had so much power I couldn't stop it when I wanted to; now I can't make it pull at all."

"Open your throttle," the mechanic said.

"The throttle is open," was the response.

"Oh, I see," said the workman, and he disappeared into the garage. In a few minutes he reappeared with a small bolt and proceeded to connect the throttle linkage so that the lever and accelerator pedal would open the throttle when moved.

What had happened was that through neglect the bolt had worked loose and dropped out so that the lever did not move the throttle arm, and advancing the lever had no effect.

This bolt probably is one of those to be found imbedded in the pavement somewhere about the city. An examination of the pavement of any of the automobile thoroughfares will reveal nearly all the fifty-seven varieties of auto accessory parts in the asphalt. A great many of the bits of metal found there will be broken skid-chain links, but the writer counted twenty-six different species of other lost parts in crossing Fifty-seventh Street at Eighth Avenue, New York City.

While counting them a driver came along and was unable to stop his car properly—the brake did not work and he had to use the emergency brake after nearly running over a pedestrian. He got out and found that a pin was gone in the brake linkage. A spring cotter had worked out or sheared off and the pin had rattled loose and dropped out.

Many of the stray parts are of a similar nature;

nuts, bolts, washers, screws, cotter pins and the like which have worked loose because of neglect. Their absence will doubtless acount for a good many of the rattles and squeaks which their former owner is now complaining of, and to replace which he will pay the garage man several times their value.

The average instruction book given with a car will advise the owner to go over the car every so often and tighten up the bolts and nuts as a precautionary measure, but usually no attention is paid to this until the car stops or develops some unusual sound. Then a mechanic is called in and it takes him a couple of hours to find the cause of the trouble, while the owner stands around cursing the maker of the car.

Probably a good many of these parts along the road are due to careless mechanics who drop small parts in the dust pan and will not take the trouble to fish them out, or leave them on the running board and after a time they jar off to the roadway; but it shows there is a lot of carelessness among drivers when they even lose number plates and hub caps.

A pair of brass hub caps picked up along the road and which have been turned into ash trays are among the writer's trophies.

The loss of the hub caps allows grit to get into the bearings and to prevent this as far as possible by making the driver take care of them, the prices of extra caps have been made entirely out of proportion to their real value by some manufacturers.

Some of the lost parts are of such shape that they would very readily puncture a tire, so that they are not only a loss to the owner of the car from which they dropped, but to the fellow who follows and picks them up for a punctured tire.

The writer has seen the pin holding in place the tie rod, which keeps the wheels in alignment, drop out, and in another case, hunting a knock, found the cylinder loose on the base because the nuts had been without lock washers, or cotter pins, and had worked loose. They might in time have worked off entirely and there would have been a "cylinder missing." He has also seen the entire engine loose on the frame so that it was doing a fox trot while running.

Drivers should keep watch of the non-skid chains, for they wear and drop cross links often. The driver who wishes to avoid personal annoyance and annoyance to everybody else within hearing distance, will take pains to see that the cross links are never so loose that they hit the mud guards, nor have broken ends which hit. A spool of wire will enable one to fasten broken or loose cross links to the side chains and repair links can be put in when the garage is reached.

The owner should become well acquainted with his car, so that he knows where the different bolts and nuts are. Many will tighten up all they know about, but do not bend their backs to get underneath where they can see the dust-pan bolts and brake-linkage bolts. If the owner knows where these parts are he should make it his business to see that every bolt and pin is locked with a lock washer or cotter pin. Then he should go over them at least once a month and tighten them up. He may be sure he will pay several times their value and a mechanic's time if they are lost, so that economy is involved as well as the inconvenience of having the car stopped on the road.

CHAPTER XLII

HUNTING TROUBLE

ORDINARILY the fellow who starts to hunt trouble finds it quicker than he expected, but not so with the automobilist; when he starts to hunt trouble —in the car—it seems to be a very demon for eluding the searcher. Trouble will hide in a tiny piece of carbon lodged under a valve or between spark-plug points, in a wire that has jarred loose, in an interrupter point, a piston ring, a gas pipe—oh, in the most secret and insignificant place—in size—and just defy one to ferret out the demon. One learns that the insignificant things are really the most important at times.

Yet most troubles incident to the operation of a motor car may be located very quickly if one will but go after them in a systematic way, and not wander aimlessly about the engine and other parts. The hardest thing a driver has to do when the engine stops or acts up is to divest himself of the idea that he knows just what the trouble is.

He is sure he can fix it in a minute and he putters around a long time before he makes up his mind that it is something else and it takes a lot of time to prove that to some persons.

The best way to go about it is to start without preconceived ideas as to what the trouble may be, and follow a system, which is really a process of elimination. Remember that to start a gasoline engine three things are necessary—gasoline, compression, and a spark at the right time, and that to keep it running it is necessary to have water for cooling, unless it be an air-cooled engine, and oil for lubrication.

If the engine stops on the road and pressing the starter pedal fails to start it, or if one or two cylinders miss fire, the first thing to do is to get the crank out of the tool kit and crank over the engine. If, with the gears in neutral, the engine cranks over hard, it indicates a lack of lubricating oil, or a lack of water, which has allowed the engine to reach a temperature where the lubricant fails to perform its work. If the engine turns over fairly easy, it is not necessary to look for oil or water trouble.

The next test is for compression. If the driver is not experienced and is unable to tell simply by the resistance to the starting crank whether each cylinder has compression, he should open all petcocks except on one cylinder and turn the crank two revolutions, noting if there is a resistance for one-quarter of a revolution in the two complete turns. Compression occurs only on one stroke of the piston in the four-stroke cycle. Each cylinder should be tested in a similar manner, opening all petcocks except on the cylinder being tested; see if the compression is practically equal in all cylinders.

If one cylinder has very weak or no compression, the trouble will be found usually in the exhaust valve. First examine the push rod to see if there is clearance between it and the valve when the valve is supposed to be closed; if there is, the valve must be lifted out and the valve and seat inspected for carbon. Sometimes a piece of carbon will lodge on the valve seat and, due to the hammering of the valve, will become fastened to valve or seat. For temporary repair generally it can be scraped off with a knife, and the valve be ground in upon reaching the garage.

If the trouble is not in the exhaust valve, it might be in the inlet valve. In some types of engines the valve head may break off and get into the cylinder and when the piston comes up punch a hole in the piston head. A petcock may be loose so that it will jar open sufficiently to affect the compression and so cause the cylinder to miss fire. These troubles usually are confined to one cylinder and not to the whole engine.

The gasoline is the next to be inspected. Is there any gasoline in the bowl of the carburetor? This may be determined by inspection, opening the drain cock, or "tickling"—flooding. If not, examine the gasoline tank and see if there is a supply; then see if the shut-off valve in the line leading to the carburetor is open; if so, drain the bowl of the carburetor to get rid of water or possible dirt. To check the possible clogging of the gasoline pipe, or carburetor screen, notice if the bowl fills up again in a reasonable time.

Do not adjust the carburetor. If the engine has been running, it is practically certain that the carburetor has not gotten out of adjustment. Inspect the intake pipe, or manifold, to see if it has been loosened by vibration. If the engine still refuses to run, put about a tablespoonful of gasoline in each cylinder and crank over the engine. If this runs the engine for a few revolutions, it indicates that the trouble is in the gasoline system and leaves but the spray nozzle, which may have dirt lodged in it, or the auxiliary air valve stuck, as the remaining causes of trouble.

Sometimes turning the needle valve a full turn and then turning it back exactly where it was will remove an obstruction at that point. Care should be taken in this to get the needle valve set as it originally was.

Next inspect the ignition system. The first thing to do is to loosen one of the wires from a spark plug and lay it so the bare end will be $\frac{1}{8}$ inch from the base of the plug, and have someone crank the engine by hand or with the starter. If a spark does not occur, go first to the interrupter points and short circuit the fixed point with a screw driver or other metal tool and see if there is a spark when the engine is cranked. Examine the points for dirt and see if they come together and open properly. Then examine the condition of the battery, testing it. Examine the connectors on the battery, which sometimes jar loose; examine the wires leading to the interrupter and switch; see if they are loose or broken or short-circuited. This need not be done if a spark shows at the interrupter.

Examine the distributor for moisture or dirt and see if the wires have become loose. If a magneto only is used, it is a simple matter to see if the interrupter points are making and breaking properly and if the distributor is clean and dry. If these appear to be all right the trouble doubtless is in the armature winding or the condenser and cannot be repaired upon the road.

The wires to the plugs may be burned or short-circuited. If, with an apparently good spark, you have compression and there is mixture passing into the cylinders, the trouble may be in the spark plug. To test a spark plug it is necessary to remove it. Widen the gap to $\frac{1}{8}$ inch and lay the plug with wire attached upon the cylinder; crank the engine and see if a spark jumps the gap. Widening the gap is necessary because the spark will not jump so far under compression as in the open air. If it does not jump, the plug may have a broken insulator porcelain or need cleaning. If uncertain about the condition of the plug, exchange it with one in another cylinder which is working properly. An extra set of plugs should be carried to replace those which become dirty; cleaning should be done in the garage.

This covers most of the usual troubles experienced on the road. There are, of course, a great many other possibilities, but if these tests, carefully made, do not disclose the cause of the trouble, the novice had better send for a garage man. If one or two cylinders miss fire, the trouble is most likely to be caused through lack of compression or a short-circuited spark plug. If the engine refuses to run, the trouble is most likely to be due to lack of gasoline, or failure of battery or magneto.

The general rule given herewith should be copied and pasted under the hood, or carried in an envelope in the tool box for ready reference. It may save much time and trouble when far from a garage. Carefully followed, it should locate almost any trouble likely to be experienced, and it is the locating, not the fixing, which takes time.

The chart on the next page was evolved out of the experience of years at the school and elsewhere. It will be found a guide in hunting trouble:

THE Y. M. C. A. GENERAL TROUBLE CHART

Above all *remove nothing from the engine* except as directed to test rules.

Needed	1. GASOLINE	Is tank full? ARE PIPES CLEAN? Is Carburetor clean? If Carburetor needs adjusting, do it, otherwise LEAVE IT ALONE. Does Manifold leak?
to	2. COMPRESSION	To test—Open all petcocks except the one on cylinder to be tested; crank engine, noticing how strong the compression is in each cylinder, in turn.
Make	3. IGNITION	A. Test for a spark by taking the wire off any plug; hold wire about $\frac{1}{8}''$ from plug; crank engine with switch on. Spark should jump to plug.
	at	B. *Are the Batteries run down?* Does the vibrator (if any) buzz? Is timer clean? Does timer rotor make *good* contact?
an	the	C. Are any WIRES loose, burnt, wet, broken, or short-circuited? Are spark plugs clean and are points $\frac{1}{50}''$ apart?
Engine	right	D. Does MAGNETO armature revolve? Is safety spark gap clean. Are Interrupter points clean and adjusted right? Do all Brushes make good contact? Is Distributor clean? Is Distributor Rotor loose, broken, or making poor contact?
Run	time	E. Check Magneto wires as per "C."

NOTE—Loose wires and terminals, neglected batteries, and dirty gasoline cause much trouble.

TO KEEP A GAS ENGINE RUNNING, cooling and lubrication and a free exhaust are necessary.

CHAPTER XLIII

MORE TROUBLE

"You may have your self-starting 6-, 8-, or 12-cylinder cars if you want them, but give me a four-cylinder motor with a crank on the front end for mine. I'll get there ahead of you nine times out of ten."

This was the boast of a chauffeur of a big car, who called at the school to inquire about some action of the motor which he did not understand. His self-starter would not start. A few simple tests narrowed the trouble to the self-starter control, and it was found in the switch, which had become dirty. From repeated arcing the spring had become heated and lost its temper and finally no contact was made, or so little that it would not supply current to start the starter. Which shows that it is a good thing to keep the temper, even in a self-starter switch spring.

This is only one instance where added conveniences have brought new troubles to the motorist.

The self-starter has made it possible for many, notably women, to drive cars, who before could not because they were not able to crank the engine. Adding cylinders has made smoother riding cars, which drive easier as well. The greater number of cylinders permits of a much quicker getaway in traffic. It allows the motor to be run at a much lower speed without shifting the gears. The motor has more power and the cars are better hill climbers; there is a better distribution of the same amount of power.

But this has made more work and worry for the chauffeur and mechanic, in that, instead of having eight valves to grind in, he may have as many as twenty-four, and if the double-valve idea is carried far enough he might have as many as forty-eight. In arranging the cylinders to procure a more even torque, in some instances it has been found necessary to locate the valves in positions where they are not readily accessible. In some types it is necessary almost to dismantle the engine, and in others the valves may be reached to remove them only by removing the mudguard.

The self-starter, while undoubtedly a great convenience, has made it necessary to take care of the battery regularly, and to keep the generator and motor commutators in condition; has multiplied the wiring—has added hundreds of wires to the car—and its numerous regulators and other instruments are bound to need adjusting occasionally. The extra care and the unusual troubles give the chauffeur a lot more to worry about.

The electric lights are undoubtedly brighter and better than kerosene or acetylene installation, but they will give trouble occasionally and the average man understands more about filling a lamp with oil than he does about locating troubles in electric circuits. Then there are electric warmers, electric heaters for passenger and driver, electric cigar lighter, limousine lights, and electric horns, which make additional wires until the traditional Philadelphia lawyer would be totally inadequate to unravel the tangle.

Suppose the ignition goes wrong and the battery seems to be all right and no cause of trouble can be found in the magneto and its wires, and the chauffeur is in a pickle. Along comes Mr. Man-Who-Knows and finds that the trouble is a short circuit in a lighting installation which impaired the ignition so that the cylinders would not fire, or fired irregularly.

The old cars did not have generators and motors; but the driver now must know how to sandpaper commutators and undercut the insulation of commutators, which is an electrical engineer's job; and he must be wise enough to know that these things are necessary because there is sparking at the commutator, and the generator is not charging the battery as it should, and the motor is not starting the engine as it ought. This, of course, is because the brushes are overriding the commutators when the insulation is not undercut, and the contact period is shortened, and perhaps some of the contacts are skipped altogether because the high speed carries the brushes over without touching the commutator.

Then, he must know, for instance, that when the lights dim while the engine is going at low speed, it is because the reverse current cut-out is out of adjustment and it requires a considerable discharge from the battery into the generator in order to make the cut-out operate, when the lights will become bright again.

Also, he must know, when the volt or ammeter needle becomes erratic, sometimes showing a big charge or a little charge or no charge at all and then comes to normal again, that he has a loose connection somewhere or the voltage regulator is not working properly.

When he presses the button of the electric horn and it does not sound, but does work right after he has kicked or pounded it, he ought to know why his rage started it working. It was simply that the brush stuck upon a dead contact point of the commutator, due to a dead armature coil, and when he jammed the horn it moved the commutator until a live contact point was against the brush and the motor started to work.

There was a time when the manufacturer pointed with pride to the fact that there were no complications on his car. There was nothing on the dash but the ignition switch, with one wire leading to the magneto. This followed a period when the dash had been filled up gradually with all sorts of devices. Ways were found to do away with them.

Now there are hundreds of wires and pipes tacked on to the dash, and the other side of the dash fronting the driver is filled with dials and gauges and switches almost without number. These all add to the comfort of the motorist, but in the same proportion they add to the worries of the driver. He pays the price of the comforts in added worries. Owners also find that these added conveniences have given demand for added technical knowledge.

CHAPTER XLIV

DON'T TAKE THINGS FOR GRANTED

DON'T take anything for granted with your car. Don't expect that there is water, or gasoline, or oil, or current in the battery, unless you have first inspected to find out. Inspect, don't expect. There are many bad habits in car practice, and one of them is the evil of absent-mindedness in locating troubles in your car.

The man who spent half an hour looking for his glasses, and then discovered they were on his nose, should not be laughed at by anyone who runs a motor car. It is only natural that this man should take it for granted they were not on his nose, yet taking things for granted, writes Harold F. Blanchard, in *Motor Life*, is the greatest difficulty that the man who has to locate trouble has to face, whether he is an amateur or an expert. A number of cases are cited to prove the point.

Everyone knows better than to crank the engine with the switch off, yet recently we saw an average motorist waste twenty minutes this way. The ignition switch was set in the center of the lighting switch handle. Therefore the absolute position of the ignition switch key varied according to what lights were on—hence the error; yet this motorist looked all over his engine before he discovered his trouble. Probably being absent-minded had something to do with it; he had just left his office for the day and was on his way home, which demonstrates that the thoughtless or preoccupied man is much more likely to make unrightful assumptions than the alert man.

Recently an old automobile mechanic was riding on an interurban car when the latter was held up by a motor car stalled across the tracks. There was a big crowd around the machine trying frantically to push it out of the way. For some reason the rear wheels were locked. No amount of effort would budge the car and it was too large to lift and carry.

The mechanic got off and watched the proceedings. He found that the gear lever was stuck in low gear, and inquiry as to whether the trouble was due to jammed gears or some other serious defect could not be answered by the owner or any of his helpers. He began to wonder where the trouble was while the others struggled, but being old in the game, the thought flashed across his mind: "Take nothing for granted." Therefore the first question to determine was whether the whole difficulty might not be solved by pushing out the clutch. This seemed too easy —too good to be true. He hesitated to suggest it, but the more he thought about it the more he became convinced, and finally he mustered up enough courage to slip behind the wheel and command the resting crowd to push. The car glided off, to the astonishment of everyone. It developed that the owner of the car had become excited when he stalled the engine on the crossing with the lever stuck in low. In his feverish haste he tried to push the car off instead of shoving out his clutch and starting the motor, and as the crowd collected they accepted the locked condition of the rear wheels as something which could not be remedied.

A motorist of ten years' experience bought a used car. He took delivery of it late one rainy afternoon. The former owner told him the car was complete, the only thing missing being the key to the tool box, which he promised to mail him early the next day. The motorist got a couple of friends and started for a ride. Finally they stopped for dinner. When they came out the owner put his foot on the starter pedal, but it stuck. He pulled up the floor boards but could not reach the mechanism. The only way was to crawl under the car and this was out of the question because of the mud. They looked for the crank under the rear-seat cushion and under the front-seat cushion, but could not find it. Quite naturally they concluded it must be in the locked tool box or else the former owner had neglected to include this very important item. They tried to locate a car of the same make in some neighboring garages without success. They jacked the car up and tried to crank it by turning a rear wheel, but the compression was too great, so they tossed the jack into the tonneau and started in search of someone who would tow the car to start it. Eventually they got the engine going. When they reached the garage the owner slipped his hand into the tonneau and he pulled out—not the jack—but the crank!

The worst is to come. The next morning a mechanic who had been in the business long enough to know better than to make unwarranted assumptions was called in. He pressed down the pedal without success, then for no logical reason but simply because automobiles were second nature to him he pulled up and the pedal came. Then he pushed and the starter worked. The owner was nonplussed. Later he admitted that he had thought of pulling up on the pedal but *assumed* it would do no good.

A few years ago, when expanding clutches were more popular, a motorist found one day that his clutch was slipping. He had a vague idea that there must be some means for adjusting the clutch to cure this trouble, but he looked in vain for a nut or a screw or a bolt which might do the trick. True, there was a small screw in the flywheel rim, set almost flush with the edge of the rim and locked by a tiny spring wire which rested in the milled slot in the screw. But he limped to a garage on low gear and held consultation with the entire force. They examined the car carefully and decided there was no way to adjust the clutch. They suggested a new lining or strips of metal under the old lining to swell it out so that it would grip. The former was out of the question because of the time it would take, so the latter was tried. The makeshift worked all right for a few miles, and then the clutch slipped more than ever. In desperation he called the agent up on the long distance, and was informed that his troubles would be over if he would give that innocent-looking screw a couple of turns. It sounded like black magic, but he went back and tried it, and his troubles ended.

An owner who was very particular about having his car in the best of condition found that the compression in the first cylinder was weak although the valves had just been ground. He removed the exhaust valve and found it in perfect condition. Then he took out the intake valve, although he felt foolish while doing it. It was in excellent shape but, just to be on the safe side and because he did not know what else to do, he ground it anyhow. The trouble was no better. Neither did the difficulty seem to be due to too small a clearance between valve stems and push rods, because the clearance was the prescribed amount on both intake and exhaust valves. He concluded that it must be the rings. Either they were gummed or broken. Flooding the cylinder with kerosene did not improve the condition, so a pint of very heavy oil was put in with the idea that this would temporarily stop any leaks between cylinder and piston, but the compression was no better. Several times during the hunt he was tempted to increase the clearance between valve stems and push rods, not for any sensible reason, because the clearance was correct, but simply in desperation. It seemed about the only thing left to do—it was the only thing he had not tried. But his "common sense" said no, so he took his car to the service station. The first thing they did was to increase the clearance on the intake valve, and the trouble was cured. The reason for doing this was that there was a high spot on the back of the intake cam which would open the valve a slight amount on the compression stroke. The clearance was increased to a point where the high spot had no effect.

One day a motorist had serious magneto trouble. The engine missed and finally stopped. It was necessary to take the magneto to an expert to have it repaired. The very day the magneto was replaced the car started missing again and it looked as if the work had not been properly done. Finally the engine refused to go further. A passing farm wagon was hailed and the car brought home—seven miles. The magneto was returned to the shop, but nothing wrong was found. Yet when it was replaced the car still refused to run. A telephone talk with the nearest agent, forty miles away, showed that the trouble might be in the carburetor and a search showed that it was—the low speed jet was clogged. To prove the truth of this suspicion the engine was primed and ran perfectly except at low speed. When the car first stalled, it occurred to the owner that it might be a good idea to prime the engine, but he dismissed the thought because he was so certain the trouble was in the magneto, and without a better reason than it was too much work to prime the engine because there were no priming cups.

A similar trouble in that it was of a dual nature was experienced with a car which had just had the valves ground and the carbon removed. After the work was done the engine could not be started. Investigation showed there was no spark. No short-circuits could be found in the wiring. The breaker points were examined and after filing and adjusting them the engine started on the first turn. Fortunately the man who did this job knew how to proceed—he made no guesses or assumptions. In this he was different from the owner whose experience was related elsewhere.

The last two instances show something it is very important for everyone to realize, although this is a diversion, namely, that repair men are often blamed for tampering with cars without cause. The preceding incident was pure coincidence. The breaker points gave out entirely when the engine was shut off prior to grinding the valves.

The various incidents which have been related prove that it is not wise to take anything for granted. It seems like a simple rule, but only those who have tried to follow it will find out how hard it is. It is also important to bear in mind that it is not wise to use too much logic in hunting trouble, for the solution is often far from logical. It is well to reason as carefully as possible, but if the solution is still to be found it often happens that it is obtained by some illogical act. Follow the general-trouble rule in an orderly way, therefore, and do not take anything for granted.

CHAPTER XLV

BLOWING YOUR OWN HORN

Of course it is your horn and you have a right to do anything you want to do with it—except make a nuisance of yourself to others—and you can toot it to your heart's content when off in some wilderness; but if you desire to live in peace and harmony with your neighbors and with your fellow travelers in this vale of tears, you will have a care when and where you toot your toots.

In olden days it was compulsory to have bells on the horse when drawing a sleigh, which was supposed to be noiseless. The bells were to give warning of the sleigh's approach around a curve or over the hill. This was the only vehicle to have a warning tone, except the fishman or the junk cart, and their noise was inviting—ostensibly—rather than warning, though often it ought to have been the latter.

Soon after the coming of the bicycle it became apparent that some means of signalling its approach must be had. Now singularly enough in the light of present-day understanding, the bicycle bell or horn was not to warn people to get out of the way. It was to warn folks that you were looking out for them and that, unless they stepped suddenly in your path, they might feel assured that you would not run into them. Everybody understood that the pedestrian had first right to the road. Bicycle riders practiced strenuously the ways to avoid the man afoot—most of them.

With the coming of the automobile the use of horns was continued, early electrics and some others using a bell. They were the continuance of the bicycle warning, and when the automobile was popularizing itself it was understood that the bell or horn was merely to prevent others from walking into danger. The autoist saw to it, so far as he could, that the man, woman, or child went safe.

Came another generation and the universal use of the automobile for pleasure, business, and transportation uses, and all of a sudden people began to talk about the rights of the autoist, and the horn began to peremptorily order folks to get out of the way or get run over. There is not the slightest doubt in the mind of the writer that the present attitude of autoists in general is due to the mistaken notion that they have rights in the roadway part of the street and the pedestrian's rights are confined to the sidewalks and crossing walks; nor that this notion was bred by the police regulations of traffic which sought to protect the pedestrian by herding him off the road to the side walks and permitting him at intervals to cross the road. It is noticeable, however, that not one arrest for refusing to keep off the roadway has ever been made—or at least sustained by court. The policeman may frown at the man who tries to go contrary to the traffic rule, but that is all.

Out of this misunderstanding there has come such a constant use of horns as to make it a continual nuisance on thickly traveled streets and even on much traveled highways in the country. And the nuisance is not from the necessary signaling to other cars or vehicles, but the unnecessary tooting the driver does because he wants everybody to know that he is coming and to understand that they must get out of the way for him.

Now a certain amount of signaling is needed in driving, but it is possible to drive through the thick traffic of New York City from the Battery to Harlem without tooting the horn half a dozen times—that is if one is a careful and well-instructed driver.

Watch other drivers and pedestrians and do not blow the horn after they have seen you, or if their direction and speed of travel is such that they will be out of your way before you get to them. If not seen, sound the horn once and be ready to stop. As a matter of fact the foot should instinctively go to the brake pedal each time the hand goes to the horn. But if you are seen by the other person why blow the horn at all?

If one is driving along a country road and desires to pass another car going in the same direction, it is customary to sound the horn once that the driver ahead may not turn his car in front of you, and so that, if needed, he may turn to the right to let you pass on the left. He is the judge as to when and where he will turn, since he can see ahead better and knows what obstructions are to be avoided. With few exceptions he will, when signaled, immediately give way; if he does not, and it is fair to presume that he heard the signal, it is polite to wait a moment before again signaling your desire.

One also should signal just before reaching the top of a hill, particularly if the road be a narrow one, that anyone coming up on the other side may know of your presence and be guided accordingly; likewise the signal should be given before coming to a cross-roads, unless there is a plain view of both roads for a sufficient distance to make sure that a collision is not likely.

Occasionally one will catch up to a farmer's load of hay, and the signal will not be heard, and it becomes necessary to toot a number of times, but this is rare. In meeting a wagon or another auto it is not necessary to sound the horn unless it is apparent that the other driver does not see you, or is keeping to the crown of the road, expecting you to do all the turning out. Well, even then, sometimes, it is better to do it, at that.

As a rule, it is easier on one's temperament, and safer in the long run, to let the fellow who wants all the road have it; therefore when you hear a speed fiend coming, his presence announced by vociferous tooting of the horn and perhaps punctuated by shouting, or oaths, draw to one side and slow up. It costs little either in time or effort, and if it happens to be a load of drunken, irresponsible loafers you will be safe. At the same time, if you have influence with the police and other officials, call their attention to persons who thus disregard others and see that they are fined and their licenses taken. For the meekness advised, in letting them have their own way, is but that you may survive to do a piece of good work for the country at large by bringing before the law those who violate all principles of courtesy and rules of the road.

Blow your own horn, if you want to, but blow it discreetly; let others blow, too, and heed the warning, lest you come to grief with them.

CHAPTER XLVI

WOMEN AS DRIVERS

THE 5.19 had stopped at Lonesomehurst, and the grating sound of the Klaxon had caused more than one commuter to wish there were a law against harsh noises. To Cholly Subbubs, however, it had a welcome tone, and he grabbed for his bundles and umbrella, saying while he dashed to the door and swung off the train as it pulled out:

"Sorry, boys; finish the game tomorrow. Wife's here with the car for me."

His partners at whist saw him step into a smart car driven by Mrs. Subbubs, who turned it about and took the road parallel with the track and for several miles gave race to the train, while sundry passengers uttered wise sayings as to the folly of a woman trying to run an auto.

A woman can run a car as well as a man [one of the commuters finally averred, as an answer to the criticism of the wiseacres]. I expect my wife will be at the next station and we will have a twenty-five-mile spin before dinner. It will blow off all the grouch, and blow out of my lungs all the bad air I have had to breathe today, and give me an appetite that would do credit to a man who has been toting bricks up a ladder rather than selling bonds.

He had told the story of the new era of automobiling which has come to the metropolis. Wife, the chauffeur! Now what is happening about New York City is an old story in some parts of the country, but the latest wrinkle in suburban travel about these parts is for friend wife to meet the train two or three stations up the line and take tired hubby for a ride on the way home. Having learned to run the car, she had been taking him to the station and meeting him at night. One night he was startled to hear her familiar signal on the horn—he knows his master's voice—some distance from the home station, looked out of the window and just had time to swing off on the station platform. Now he is keen for that sound. Probably every commuter train which leaves the city each evening in pleasant weather has several such scenes.

It is not a fad, either, but the solution of the fresh-air problem for pent-up business men; the relaxation from the daily cares and just the most delightful visit with each other that devoted ones can have. In the summer evenings there is time for a long ride before dining; in the cooler evenings of fall and winter, when dark comes before hubby is due, good roads still are inviting and the crisp air rejuvenates one and creates an appetite which is alarming, the high cost of living considered.

Women in the East began to take an interest in running an automobile about the time the self-starter was put on the market, three or four years ago. Cranking is not a feminine job and old models of cars bore no semblance in convenience and ease of handling to those now on the market; they are more reliable and dependable than the ancient makes.

Then, too, women in New York are used to being waited upon. They are not of the aggressive type, and do not care for man's work; while in the West they are more self-reliant. That is only natural, since the western women have been thrown more upon their own resources; having helped the men subdue prairie and forest and desert, the younger generation has not departed from their footsteps. There are self-reliant women in New York, of course, but of a different type, and one would hardly expect them to want to own or operate a car themselves; but they are beginning to, by the thousands.

Another reason for the slowness of women to take up auto driving is that New York City is not a place for pleasure driving; but in the suburbs they are taking it up rapidly, as the increasing daytime honk-honk indicates. In the city it is unnecessary, for there is every convenience for shopping or calling at beck and call—taxis, buses, and rent cars. These things are not to be had so largely in the suburbs, and when hubby is at business and the chauffeur is at his grandmother's funeral, or has too heavy a load of "Oh, be joyful," for safety or pleasure, it is a case of stay at home, or learn to run the thing for herself. She learns, and then does not have to worry about the chauffeur going around the corner for a highball while she is calling.

So far as mastering the mechanical and technical details of a car, women seem to be just as apt as most men, if they take it seriously enough. The fact that mechanical talent is not limited to the male sex is indicated by the numerous automobile developments which are the product of the feminine brain.

The Y. M. C. A. Automobile School has been taking women pupils for three years and among the four hundred graduates have been every type, from the society debutante to the mature matron, chorus girl, actress, and a few who desired to become professional chauffeurs—"Jit Chicks" they call them in Philadelphia—with a lot of applications from school teachers. It does not appear why so many of that class have taken the course, but one of the instructors says that most of them are learning so that at vacation time they can take their car instead of the ocean steamer or railroad train and spend two months "seeing America." One of them, however, declares that she intends to become a professional chauffeur during vacation, so that she can make money while enjoying a full relaxation from her ordinary labor. She teaches at an exclusive club-colony center and will run her car there.

When the first woman applicant came, it caused some of the instructors to gasp:

"Why, a woman cannot understand an engine."

"Only because they never have tried," was the response. "Give me a chance—I'll show you."

"But you would get all dirty. The men have to crawl under the cars and get covered with grease and grime," was objected.

"If they get any dirtier than I did this morning when I had to clean out the kitchen stovepipe,"

SHE IS ACCUMULATING KNOWLEDGE OF AN INTRICATE MACHINE—AND SHE IS FASCINATED

was the comeback, "then I'll give up; grease has no fearsomeness for a housewife."

Of course the director gave in, as man ever has yielded to woman, and today the women's department of the school is a fixture, for woman has demonstrated that she can understand machinery and wires and things and learn how to pilot a car and do all sorts of other stunts with it.

It is no child's play to which the woman student is ushered when beginning the course. She goes right at a machine and first of all has to learn what the array of bolts and valves and belts and wires is for. The women put on big aprons—or overalls—and gloves, and with sleeves rolled up start to dissect one of the cars as a doctor does a cadaver. From starting crank to differential and from spark plug to oil sump it all has to come down, and, worse yet, has to be put together again. The dainty young thing in dimity—under the jumper—gets her arms greasy and a splotch on her nose, but she doesn't care a bit, for it all washes off and she knows that back of the nose she is accumulating something that won't wash off—a knowledge of an intricate machine—and she is fascinated.

She has to learn about tires, too; how to take them off and repair and replace them. It is just a bit odd to see a woman patching an inner tube as handily and as daintily as though she were embroidering a bit of Christmas frumpery; but really she handles the shears to cut the patch a lot more readily than most men, and she puts the patch in place as carefully as though she were mending the seat of her young hopeful's rompers.

When the student has mastered the mechanical part and has overcome all the "queering" the instructor can devise, she is taken out for road experience. When she has the car ready, supplied with gasoline, lubricating oil, water for the radiator, and all the other things which make for safety and successful operation, and has cranked the engine, unless there is a self-starter, then, with hands and feet engaging the steering wheel, levers, and pedals, the momentous hour has come when the machine is to be under her control. The instructor is provided with a duplicate set of levers for an emergency. Lessons begin in the quiet streets, gradually emerging into those busier, until at last Fifth Avenue and Forty-second Street, the busiest intersection in the metropolis, is reached.

The women always enjoy that. Never one but shows she is having the time of her life at that corner. They are expected to lose their heads and "go up in the air," but they do not. They are not so reckless as men, are quicker to grasp a situation, and do not "take a chance" as men do. Alertness is an attribute of most women, also intuition, and these are qualities needed by an auto driver.

The era of low-priced cars undoubtedly has had something to do with the influx of women into auto driving. Thousands to whom a high-priced car with liveried chauffeur must ever be a dream, are able to have a moderate or low-priced car for the whole family. Mother will not let her sons and daughters distance her in anything, so she learns too.

Whatever may be the cause, it is a fact that the women of the country are taking up the auto seriously. There already are too many in the city streets to excite even casual notice, but in the suburbs, where there is an almost total absence of men during the daytime, every car you meet has a woman at the wheel. There is no indication, however, that man has been relegated to the care of the nursery. He still is too valuable as a producer for that—producer of gasoline and tires and what not. But the chauffeur who drives for a living must take account of the woman at the wheel, for it means lessened opportunity; still, the use of trucks is increasing, and woman is not likely to be a competitor there—not yet.

CHAPTER XLVII

MISCELLANEOUS RULES

BELOW are given a number of rules for doing things about an automobile, which may help the novice remember the instructions heretofore given by the agent from whom he bought the car, or obtained at the service station, in the manufacturer's book of instructions, or elsewhere.

FOUR THINGS TO DO BEFORE LEAVING THE GARAGE

Be sure there is plenty of water.
Be sure there is plenty of gasoline.
Be sure there is plenty of oil.
Be sure there is plenty of air in the tires.

FIVE THINGS TO DO BEFORE CRANKING THE ENGINE

Be sure the emergency brake is set.
Be sure the gear-shift lever is in neutral position.
Retard the spark fully.
Open the gas hand throttle about one-third.
Throw switch to battery position.

THREE THINGS TO DO AFTER CRANKING

Close the throttle until the engine idles.
Advance the spark about two-thirds.
Switch from battery to magneto.

TO ADJUST A CARBURETOR

Adjust the needle valve at low speed—engine idling.

For high speeds adjust the auxiliary air valve.

(Owners should learn the make-up of their carburetor before attempting to adjust it, and should first watch someone who knows how to do it.)

TO ADJUST CAM SHAFTS WHICH TIME VALVE OPENING AND CLOSING

Make sure that push-rod adjustment is right—that a thin card will pass between push rod and valve stem when valve is closed.

Determine direction of rotation of cam shafts.

Set fly wheel so that the mark 1 T. C. (top center) registers with pointer.

Turn fly wheel until mark 10° P. T. C. (past top center) registers with pointer.

Rotate exhaust cam shaft in proper direction until the exhaust valve of No. 1 cylinder has just closed.

Rotate inlet cam shaft until inlet valve of No. 1 cylinder is just about to open.

Mesh the gears and lock them in place.

If No. 1 cylinder is right the others must be.

RULE FOR TIMING THE MAGNETO

Find the firing order of the engine.

Turn crank shaft of engine and note directions in which armature and distributor of magneto should revolve.

Set No. 1 cylinder on beginning of power stroke by watching exhaust valve just close and then turning crank one complete revolution.

Set fly wheel so that mark No. 1. T. C. registers with pointer.

Retard spark fully—by moving breaker box in same direction as arrow points or armature rotates, as far as it will go.

Rotate armature in proper direction until interrupter points are just about to open.

In this position mesh gears and lock magneto to base.

At this point prove your work by advancing spark. If points are right they will open.

Notice what point in distributor the rotor is touching. This goes to No. 1 cylinder.

Wire distributor in firing order of the engine.

(The distributor always rotates in opposite direction to the armature.)

RULES FOR CARE OF CLUTCH

To remedy a harsh gripping leather-faced cone clutch, apply neatsfoot oil or castor oil to leather face.

To remedy a slipping leather-faced cone clutch, apply fuller's earth or French talc to leather facing. In rare cases a little gasoline may be used.

To remedy a harsh gripping multiple disc clutch that runs in oil, add engine oil to the mixture.

To remedy a slipping multiple disk clutch running in oil, add kerosene to the mixture.

Too little spring tension will cause slipping.

Once every 100 miles turn down all grease cups on the clutch.

Once every 500 miles apply neatsfoot oil to a leather-faced clutch.

Once every 1000 miles drain a multiple disc clutch and clean thoroughly with kerosene and renew the oil.

RULES FOR CARE OF TRANSMISSION AND DIFFERENTIAL

It must be kept half filled with very heavy oil. (Consult manufacturer's instructions.)

Once every 500 miles inspect and replenish lubricant if need be.

Once every 5000 miles drain case, clean thoroughly with kerosene, and renew lubricant.

RULES FOR CARE OF OTHER PARTS

Once every 1000 miles pack universal joint with very heavy grease.

Once every 250 miles use oil can freely and turn down all grease cups on torsion and radius rods.

Pack the wheel hubs with grease every 1000 miles.

Pack the steering worm housing with medium grease every 500 miles.

Oil the steering mechanism every 100 miles and turn down all grease cups.

LUBRICATION TIME-TABLE

Lubricate as often as is necessary. The safest rule always is to follow the manufacturer's instructions.

Every 100 miles: Use oil can freely; turn all grease cups down two or three turns.

Be sure that these parts are well lubricated: Steering apparatus, clutch, spring-shackle bolts, crank handle, fan, valve-rocker arms, wheel hubs.

Every 250 miles: Give same care to braking apparatus, emergency brake, and gear-shift levers, and rocker shafts, water pump, torsion and radius rods. Clean force-feed oil system.

Every 500 miles: Inspect transmission and differential cases and refill if necessary; pack steering worm housing; apply neatsfoot oil to cone clutch facing; clean gravity and circulating splash systems.

Every 1000 miles: Pack universal joints, ball and socket boots, hub caps; oil magneto, electric motor, electric generator; clean disc clutch; clean splash system; lubricate spring leaves by jacking up frame of car, spreading leaves apart, and putting graphite mixed with gasoline between leaves.

Every 5000 miles: Drain transmission and differential cases and clean with kerosene and renew lubricant; clean wheel bearings and repack hubs with grease.

Give all bearings a careful inspection and take up all play.

CARE OF STORAGE BATTERY

Keep electrolite over top of plates by adding distilled water.

Keep top of battery clean and metal parts covered with vaseline to prevent corrosion.

Keep holes in vent plugs open.

Never leave battery standing in a discharged condition.

Make sure it is tightly fastened on car.

Examine battery once a week in summer; every two weeks in winter.

Take hydrometer readings at these times; never take hydrometer reading immediately after adding water; wait fifteen minutes for water to mix with electrolite.

If one cell always needs water examine for leaky container.

INDICATIONS OF A DISCHARGED BATTERY

Starting motor cranks engine slowly or not at all.

Lamps burn dimly or not at all.

Lamps burn brightly when first turned on but soon dim.

Electric horn weak.

Low specific gravity of electrolite.

CAUSES OF DISCHARGED BATTERY

Generator not charging battery.

Generator belt slipping.

Wires short-circuited or grounded.

Plates not covered with electrolite.

Defective or leaky cell.

Excessive lamp load.

Excessive use of lamps when engine is stopped.

Car not being run fast enough to charge at sufficient rate.

Using starter too much.

Cut-out not working properly.

Broken or loose connection between generator and battery.

(Storage battery efficiency in winter is half that of summer.)

LOCATING TROUBLES IN LIGHTING AND IGNITION SYSTEM

If no charge shows on dash meter when engine is running at speed equal to 15 m. p. h., connect good ammeter in series with dash meter; if this meter shows proper charging rate, trouble is with dash meter; if it also shows no charge, connect voltmeter with generator terminals. If it indicates a very high voltage, generator is O. K. and trouble is between generator and battery.

Test cut-out and examine all connections and wires.

If lights light when engine is stopped, trouble is between generator and ammeter. If lights do not light, trouble is between ammeter and battery.

If no, or low, voltage is indicated, trouble is with the generator, regulator, or wire between generator and regulator.

If starting motor will not crank engine, make sure battery is O. K., connections bright and clean, commutator and brushes in good condition, and that starting switch makes good contact. Crank engine by hand to make sure some mechanical defect is not preventing engine from turning.

If starting motor spins but does not crank engine, pinion or drive gear may be loose, chain broken, or overrunning clutch slipping. If a Bendix drive, pinion may stick in worm due to dirt in threads.

If none of the bulbs light, examine connection at battery, ammeter, lighting switch, and wires between those units for breaks; also all the bulbs may be burned out.

If a grounded system, examine ground connection at frame.

If only one bulb fails to light, trouble must be in its own circuit. Take trouble lamp or voltmeter and test at contacts of connector at lamp. If you get current at this point, trouble is with bulb or contact pins sticking, or not long enough. If you do not get current at this point, examine fuses, connections at lighting switch and connectors; also wire for breaks.

As a short circuit on the car generally shows its presence by its effect on battery, preventing it from holding a charge, if meter shows discharge all the time, remove wire from meter or battery. If needle remains on discharge, needle is stuck; if it drops to zero, there is a short circuit or cut-out does not open.

A short circuit beyond the lighting switch will not show on the meter until switch is turned to circuit in which short circuit is located. This will cause lights to dim and show a heavy discharge on meter.

As there are other circuits whose current does not pass through meter, a short circuit in them would not be indicated on meter, but would be indicated by running down of battery. To locate, remove all bulbs, also all wires from one of the battery terminals. Connect one side of the trouble lamp to battery terminal and the other side of lamp to wires removed. Any current leaving the battery must now pass through the trouble lamp causing it to light.

1—If trouble lamp lights when lighting switch is turned off, short circuit is either in starting motor-circuit, generator circuit (or cut-out does not open), horn circuit, or in wires between lighting switch and battery, or in ignition circuit. Eliminate one circuit after another until trouble lamp goes out. Then examine circuit on which it goes out for short.

2—If trouble lamp lights only when lighting switch is on, short circuit is in circuit beyond lighting switch. Examine circuit indicated on face of switch when in position that trouble lamp lights, as switch can be divided into sections. Eliminate one section after another until trouble lamp goes out; then examine this circuit for short.

CHAPTER XLVIII

THE GOLDEN RULE OF MOTORING

This volume does not pretend to set a standard of manners for owners of automobiles, nor does it profess to be a first-aid course in courtesy, much less suggest lessons in gentlemanliness, which might as well be called gentleness at once; yet there is sad need of instruction in all these things, if one may judge by the experiences of the road and of the inn and garage stops along the way.

Now the writer believes that the American citizen is a gentleman to the manor born, of natural right and disposition, and that he does not leave his manners at home, as he is supposed to leave his religion at the church door. A gentleman in the drawing-room will be a gentleman on the highway. He will not be a boor because the man he happens to meet is one, not even if the majority are.

Why is it, then, that there is an utter absence of courtesy, or if there be an occasional display of good nature it but emphasizes the lack of it in general? Undoubtedly this is a fair statement of conditions in and about the metropolis. It is not true to anywhere near the same extent in the Western country, and "Western" ought to be understood in this connection as anything west of the Alleghany range.

The writer has been astounded on several occasions in Denver and other Western cities at the really human spirit of the drivers. They actually stopped of their own accord to let the writer, a pedestrian at the time, cross the street, and did it in so gracious a way as to make it seem a real pleasure. Picture that on Fifth Avenue, New York City, or upon any of the highways out of the metropolis on a Sunday or holiday in warm weather.

But it is not alone in the attitude of the driver toward the pedestrian that there is remissness, but in the behavior toward other drivers that there is need for improvement. What is easier than to cheerfully make way for the man who wishes to pass by, or to turn aside as much as may be necessary for the other car we meet; to slow up at the intersection, instead of spurting to get ahead of the other fellow, and making him jam on the brakes to avoid a collision? Why is it necessary to try to get the best of the other fellow, as though driving were a contest of wits and that skill on the road consisted in "beating the other fellow to it?"

Perhaps the answer to all this criticism is that in and about New York, where there is a dense population, there are thousands of drivers who are not from the ranks of the well-bred, by which is not meant the wealthy. The low price of cars and the thousands of used cars on the market has put them at the disposal of the butcher boy and the hod carrier and bell hop, and they seem to have the idea that the driver of a car possesses superior rights over others and must assert it. Out in the land where folks have a chance to open their lungs and breathe, a broader view of life is held. It is a fact, however, that the well-to-do families of the East are more and more requiring of their drivers that they follow the golden rule and not the Eben Holden brand. You remember Eben's version: "Do unto others what they are trying to do unto you, and do it fust."

Secretary of State Francis M. Hugo, of New York, recently delivered an address to a group of students in which he said a number of pertinent things concerning the operation of cars, based upon his own experiences. It is so good that it is reprinted here:

I

It is not too much to say that the future of motoring largely depends upon the behavior of motorists and their drivers toward the public. As fewer owners of large touring machines drive their own cars nowadays in proportion to the number driven than used to be the case, it is, therefore, mainly the behavior of their drivers on the road that is important. The subject of the training of the motor man is consequently worth much attention, and that the automobile community as a whole realizes this is evident not only by the establishment of various schools, where the mechanical side of the profession is taught to the future driver, but by the efforts of various clubs and associations, notably of the Y. M. C. A., who have started schools all over the country to help in this training.

For the past few years, those who drive motor cars for wages have been called "chauffeurs," a word against which a protest should always be made on the double ground of etymology and nationality. To begin with, the word in reality means "stoker." On the foot plate of a French locomotive the driver is called "mechanicien," while the fireman is designated as the "chauffeur." In the case of motor cars propelled by steam, the word "chauffeur" may thus be held to be remotely correct, but on the ordinary car propelled by the internal combustion engine or by electric power, there is no sense in the term. In the best

French circles also, the word "mechanicien" is always used to designate the driver of a car and the word "chauffeur" even in France is said to be becoming obsolete.

The motorman, as he will, therefore, be called, is very often the subject of much discussion and sometimes of irrational abuse. Of course, there are black sheep in this profession, as in every other, but one is glad to place on record that black sheep were far more numerous five years ago than they are now. No one who observes without prejudice the behavior of motor-car drivers in New York City and elsewhere can help being struck with the careful way in which private motor cars are now driven, the neatness and cleanliness of the men themselves, and the vast improvement which has taken place in their general manners. Formerly, it was thought to be the highest mark of the profession that a motorman should be dirty in every respect, and a greasy cap, black hands and face, oily clothes and, as a rule, a half-smoked dirty cigarette in the side of his mouth, combined with a contemptuous scowl at every passer-by, was not an uncommon sight.

This state of things, however, has changed for the better. Occasionally a specimen of the primeval driver is met with, and even now the habit of cigarette smoking when in charge of a car is supposed, by the younger and less intelligent men of the profession, to confer an air of knowledge coupled with disdain. In course of time this form of swagger will die out also. The manners, moreover, of many motormen to their employers and to their fellow servants have not in the past been all that could be desired, but as stated before, their general behavior is markedly improving, and it must be remembered that, motormen are greatly superior in intelligence to most of their predecessors.

It need hardly be noted here that much depends upon the way the motorman has been trained. When automobiling was just beginning the only person available who even half knew the somewhat complicated machine of the early days was the mechanic trained for a few months in the shop where the car had been manufactured. He was master of the situation because he alone had working knowledge of its parts. No one in those days thought for one moment of a motorman from the viewpoint of good driving. The owner of the car, above all, desired to possess a good mechanic, for breakdowns were numerous and varied and half of the expenses of motoring were necessitated by renewals of parts or adjustments due to ordinary wear and tear. Nowadays serious or even insignificant breakdowns are rare, and there is hardly a first-class make of car in the market which will not run many thousands of miles without anything being necessary in the way of repairs and adjustments. Those which are necessary are, moreover, of the simplest kind. There is no longer, therefore, the same necessity for the motorman to be what is called a really good mechanic, so long as he understands the general principle on which the engine works and the arrangement of the gears.

The majority of motor-car owners have, therefore, changed in their requirements. They do not want a man who is primarily a skilled mechanic, but they do ask for a skillful driver, and on this wise alternative in the chief qualifications demanded lies a good deal of the reason for the great change which has taken place in the behavior of the motorman in the city and out of it. It may be remarked that an excellent mechanic is not necessarily a good driver, though he may be so in certain cases. What is required in the driver besides the general knowledge of the machinery is a knowledge of the customs and courtesies of the road and the habits of traffic, the possession of the qualities of alertness, foresight, and consideration for others. Above all, he should have a temperate frame of mind, an abstinence not only from drunkenness, but drinking in any but a most moderate sense. The driver of an ordinary wagon is conspicuous by his ignorance of the way to drive and his want of consideration of other traffic. He is the most persistent moving obstruction which exists. The motor-car driver, on the other hand, has to be the best driver on the highway if he is to drive without offense to the public and danger to them and himself, for he has to conduct a vehicle which is more valuable than any other and far and away more speedy though more handy, and, therefore, whose meeting with and overtaking of other vehicles is many times more rapid. In addition to these, he has to consider other dangers of the road to which other vehicles are not so liable and which come from the construction of its surface.

The complete motorman should have a working knowledge of the different materials of which roads are made, of their comparative tendency to cause skidding, and of the perils which arise from excessive and badly laid street-car tracks. He must know and continually practice the courtesies of the road and learn its manners and customs. He must be observant and realize that children hanging on the rear of wagons are liable to drop off suddenly and run across his path. He must be on the look-out for pedestrians, stupid, drunk, or deaf, for wagons on the wrong side of dangerous corners, and to be prepared to find vehicles in charge of sleepy drivers who will often do the wrong act on awakening. It will, therefore, be seen that the motorman to be really good has to be the best driver on the road and that the standard demanded must necessarily be high. He must possess exceptional qualities as compared with the horse driver. The question is, therefore, all important—What are the best methods of training such a man?

There is no doubt that many of the schools which are teaching elementary mechanics to the would-be motorman are excellent in their way. But there are many which are nothing but frauds. Reports have frequently been made to the State where a man has complained bitterly of having put down $25 or $50 in return for which nothing but most elementary instruction has been given and this often in the worst possible way. There has been no teaching in traffic rules or on the road, or, if given, so little as to be of no use. But at other places pains are taken, and, by diagrams in the class-room and practical teaching on the road much has been taught. There are also nowadays hand-books galore which teach the construction, repair, the common faults and likely failings of the gasoline engine from A to Z. The mechanical side may, therefore, be said to have been amply provided for.

But this is only the less important, though necessary, part of the training of the modern motorman. What is really needed is that some school should teach manners on the road and the habits of traffic,—in short, train its men for the road. There should also be problems of difficult but ordinary situations in traffic set in a written examination, the correct solution of which should be obligatory before the motorman could be said to be properly trained. It is not, perhaps, easy to see at first how this sort of instruction can be given on the present scale of fees, but the schools in the future, which devote a large part of their attention to teaching the rules of the road and its customs and courtesies will assuredly turn out the best class of drivers, who will be in the greatest demand.

To begin with, the habits of horse-drawn vehicles should be studied. It is a liberal education to take a journey, for instance, on the top of a Fifth Avenue motor bus and watch the way in which the driver drives his unwieldly vehicle through the streets of New York. Other bus drivers also are rapidly becoming his equal, and let it be acknowledged that nothing but the hard school of practical, every-day experience in New York City streets, assisted by police supervision and the fear of dismissal for carelessness or accident, could produce such able drivers.

Again, the expert taxicab driver might be taken as an example of a faster class of motor traffic. The would-be first-class motorman when being trained would thus have the experience of horse vehicles and pedestrians, and have noted carefully what usually happens and have tried to understand their point of view. This is one of the first steps which should be taken in training the driver of the swift mechanical vehicle. Then example might be given of the proper way to drive cars around corners, both right-handed and left-handed, and the best manner of the ascending and surmounting steep gradients or negotiating high bridges. Driving at night should also be practiced, and prospective drivers should learn to distinguish the faint glow on the road ahead which designates the presence of a motorcycle and other signs denoting persons or vehicles. Map reading should also be a part of his instruction.

And there is yet one other thing which the motor-driving school should inculcate, though it could not technically teach the motorman—that is, good manners to his employer and his employer's friends. To be rough and rude is a disgrace to any class, and it is the mark of a man who is either not certain of himself or is afflicted with an innate bad temper. It is not, and never can be, a sign of superiority. A respectful and civil attitude not only makes the path of life easier, but is in itself a strong recommendation. Little things which do not at first seem to matter, and are merely more in the nature of courtesy than servile attentions, should be observed. A civil salute when the owner first addresses the motorman, the readiness to help in any little matter, such as carrying a bag to the station, or the thought of a rug to cover the lap, and similar little courtesies, are the sign of the man who, if considerate in these little matters, is likely to be considerate in others more important. It also establishes him firmly in the estimation of his employer.

To sum up, the perfect motorman, though he should possess as much knowledge of mechanics as possible, should, above all, be a considerate driver, well versed in the manners and courtesies of the road and the habits of traffic. And in addition, he should try to be well mannered, as more and more motor-car owners are becoming convinced that, besides knowledge, "Manners maketh the Motorman."

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