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NEW 20TH CENTURY HAND BOOK — NO. 4

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HOW TO OPERATE A MOTOR CAR

BY

A. HYATT VERRILL

STREET & SMITH CORPORATION
PUBLISHERS — NEW YORK

How to Operate A Motor Car

With an Alphabetically Arranged Chapter, devoted to Car Troubles, their Causes and Remedies : : : :

By
A. Hyatt Verrill

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How to Operate a Motor Car

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INTRODUCTION

This book is not a treatise on the mechanics of the modern automobile, nor is it intended as a complete manual covering all classes and types of motors, cars, and equipments. To treat adequately such a broad field would be impossible in a work of the present size and scope, for there are hundreds of motors and motor-driven vehicles, each of which varies in minor details; while many portions of the equipments or accessories would require special volumes in themselves. Ignition and starting devices, generators, electric lighting, and other electrical equipments form an immense subject quite apart from the mechanical side of the motor car, and unless the owner of a car is an expert electrician, it is wisest to let the electrical equipment severely alone, save for minor adjustments and repairs.

But there are many points in common in all cars and motors, and every owner or driver of a motor vehicle should be familiar with the principles of the car and its motor, should be able to locate and remedy ordinary troubles, should understand the requirements of his vehicle, and should be as fully alive to the shortcomings, the dangers, and the limits of his car and motor as to its good points, its safety, and its ability. The modern car has been developed to such a high degree of efficiency, that people, as a rule, abuse their cars outrageously, and the wonder is that there are not more accidents, more breakdowns, and more troubles. The motor car is a very highly perfected and delicate piece of ma-

chinery, and, like every other piece of machinery, it requires proper care, intelligent handling, constant attention, and a modicum of mechanical knowledge on the part of its operator in order to deliver its full efficiency, fulfill its purpose, and stand up to its work satisfactorily.

If rattles, knocks, and pounds are neglected, a car may soon be ruined, whereas a few minutes' attention and a little care will not only eliminate the unpleasant noises, but will save expenses and possible accidents in the end. "A stitch in time" is especially applicable to motor cars, and if every owner or driver would take a "stitch in time" there would be fewer accidents, fewer complaints, and fewer discarded cars. Even such important matters as lubrication are neglected until too late in many cases; for there seems to be a rather prevalent idea that, as long as a motor will run and a car will travel, nothing else matters. As a matter of fact, attention to the little things is what counts most in the long run. No one would think of driving a horse until he falls exhausted or dead in the road, and few would ride in a carriage with squeaking axles and noisy springs; but there are scores of cars in daily use which groan, squeak, rattle, and protest at every yard they travel.

It is not necessary to be a mechanic, an electrician, or an engineer in order to care for your car, to remedy the ordinary troubles which arise, to make adjustments and simple repairs, and to recognize and locate the cause of any unusual noise, action, or behavior, and by remedying it, prolong the life and efficiency of the machine; but even if you do not care to attend to these matters personally, the knowledge will save you many vexatious delays and unnecessary expenses, for if you know what the trouble is, and what should be done to remedy it, you

will not be at the mercy of every unprincipled garage proprietor or mechanic who does your work.

Much of the life and efficiency of a motor car depends upon the way it is operated and driven, not to mention the danger to life and limb which results from incompetent drivers and, strange as it may seem, very few people who drive motor cars are really competent.

It is to aid the inexperienced, to point out the most essential matters for attention, to serve as a handbook and guide to the owners and operators of motor cars, especially the beginners, and to aid them in securing greater efficiency and more pleasure from their cars that this book has been prepared. It is not intended to cover all types of cars, motors, or equipments, but to cover in a general way the standard types. Certain cars, such as the Ford, Metz, et cetera, differ in some ways from the standard cars, but the distinctions are mainly in the methods of control, and the makers of these cars furnish excellent books of instruction which will provide ample information in these matters.

The principles of operation, the motors, most of the mechanical details, and the method of driving, aside from control, are the same in all cases, however, and the chapters on these subjects, as well as the information regarding troubles and their remedies, are equally applicable to every make of car.

Considerable space has also been devoted to the chapters on driving, accidents, rules of the road, et cetera; for it is just as important to know how to drive a car properly, how to avoid accidents, and how to act in emergencies as to understand the mechanism of the car.

Many people consider a motor car a dangerous thing, and forego the pleasures of motoring through fear of

accident. They constantly read accounts of accidents and fatalities, but they seldom stop to consider the thousands of cars in use, the tens of thousands of people using them, and the hundreds of careless, incompetent drivers who handle them. Used and operated with intelligence, a motor car is no more dangerous than a horse-drawn vehicle. In fact, it is far safer, for, unlike the horse, it has no whims, caprices, or will of its own, and properly handled by a cautious, cool-headed, and skilled driver, the automobile may be safely driven where it would be impossible to drive a horse and carriage. But, like many other harmless things, a motor car may become a fearful engine of destruction if improperly used, and there is no more sense or reason in condemning motor cars as dangerous than for opposing the use of railway trains, trolley cars, or even elevators, just because accidents have happened through their use. Remember the slogan, "Safety first," and let your watchword be *safety first, last, and all the time.*

HOW TO CHOOSE A MOTOR CAR

There are so many makes, styles, and types of automobiles on the market that it is often very difficult for the prospective purchaser to decide which he should buy. Moreover, every manufacturer and dealer will claim his car is the very best value for the money; he will point out innumerable features which he claims are not possessed by the cars of his competitors; he will boast of the low upkeep cost, the simplicity, the saving on tires, the economy of fuel, and the countless other advantages of his car. Finally, he will dwell at length on the paint and varnish, the upholstery, and the exterior finish of the car he is trying to sell. Strangely enough, if the car he is boosting is a standard make, his claims are probably all borne out by facts. Although, to the uninitiated, all cars may seem much alike, in reality each has an individuality, certain details, little refinements and improvements and particular advantages of its own. But competition is so keen, cars have been developed to such a standard of efficiency, and the public has learned to look for and demand reliability and performance to such an extent, that unless a car is really good value it has little chance of a market.

At the same time, there is a vast difference in the economy, the performance, the life, the comfort, the simplicity, and, most of all, the prices of various cars. To the average purchaser, price is a very great and important factor, and when the man of nonmechanical bent starts forth to buy a car he is confronted with prices

ranging from five hundred to ten thousand dollars, and, in many cases, he cannot see where the difference of several thousand dollars comes in. As a matter of fact, in a great many cases the difference is entirely a matter of finish, of stylishness, or of name. But, on the other hand, there is a vast difference between a cheap car, a medium-priced car, and a high-priced car in materials, workmanship, mechanical details, and efficiency. Not that the low-priced cars of to-day are cheap in the sense of being poor value, for, dollar for dollar, many of the lowest-priced automobiles give greater value than their higher-priced rivals; but it is manifestly impossible to put the same grades of material, the same careful work, and the same mechanical perfection in a cheap car as in an expensive one. Moreover, each type has its own field, its own advantages, and its own purpose, as well as its own disadvantages, and the first thing to decide is which is best suited to your own particular needs. Perhaps the most important matter is price. Unless you're a millionaire there is probably a limit to the amount you wish to invest in a car, and by crossing off all cars which cost more than you have decided to spend, you will eliminate a very large proportion of the cars on the market. Next, decide upon the purposes and the uses to which your car is to be devoted. If your family is large, it is useless to get a small car or a car too light to accommodate the passengers you will wish to carry. Whereas, if you are single or require a car for only two or three passengers, it is foolish to purchase a big touring car. If you intend to take long cross-country tours, you'll need a car that can stand up to the work, a car that will not develop rattles and squeaks after a few thousand miles, a car that will be economical and that will insure com-

fort and easy-riding qualities. Then, too, you'll need a car that will have enough power to pull out of sand, mud, or ruts, and that will take any reasonable hill without difficulty. On the other hand, if you intend to use your car for business purposes, or to use it about town, or only for short day trips, a far lighter, smaller, and lower-powered car will serve just as well. Finally, there is the question of upkeep and economy. Most modern cars are, comparatively speaking, economical, and with proper care and attention their upkeep is not excessive, but you cannot get the same fuel or tire mileage from a heavy, high-powered car as from a light, low-powered car; and don't forget that the fuel consumption, the tire mileage, and such data presented by the manufacturers are based on tests by experienced and skilled drivers and mechanics under the most favorable conditions, and with everything adjusted and tuned to the highest state of perfection.

Having thus decided upon the price you will pay, the type of car you desire, and the purposes for which it is to be used, study the mechanical side of the matter, and compare, point by point, the various cars which remain on your list as possibilities. Don't be guided by paint or finish—paint is about the cheapest thing on a car; and while details of finish are all very well, if everything else is equal, upholstery, color, varnish, and such things do not make a good motor, long-lived mechanism, or efficiency. Don't be swayed too much by what your friends tell you of their cars. The satisfaction a car gives depends very often upon the individuality of the owner, and what suits one may not suit another; people can no more agree on cars than on cigarettes or food.

First, look for a car with standard parts. Some cars

are manufactured from end to end in one plant, while others are partly manufactured by the makers of the car and are partly assembled or built up of parts from one or more other manufacturers; while still other cars are completely "assembled," and few, if any, parts are actually made by the firm turning out the finished car. If the various parts of an assembled car are made by reliable and well-known firms, they are probably equal to the parts made by the car manufacturer, and as these accessory makers specialize on the parts they make, their product is often superior to similar parts found in cars built in one factory. Certain motors, for example, are used in many of the best cars, and if the car you have in mind is powered with one of these standard, widely known, and acknowledged firms you need have no fear as to the engine's quality and performance. The same is true of axles, bearings, gear shifts, transmissions, differentials, et cetera; but because each of these various parts is in itself of recognized high quality, it does not follow that the car as a whole is equally good. There may be carelessness in assembling, the chassis may be weak, the car may be too light or too heavy for its power, the body may be poor, or there may be some little, unsuspected detail which detracts considerably from the value of the car as a whole. Hence, as a rule, it is preferable to buy a car which is made throughout in one plant.

Don't buy a car in which everything is not easily accessible. Nine times out of ten if anything goes wrong it will happen where it is difficult to reach, and you do not want a car which has to be torn all to pieces to get at some little bolt, nut, or adjustment. There is mighty little fun in paying a repair man twenty or thirty dollars for time required to take apart and reassemble your car

in order to make a repair that in itself should take ten minutes. There has been a most praiseworthy tendency to make cars accessible within the past few years, but there are very few which are accessible enough to-day. Look for simplicity, also. If under the bonnet you see a complicated multiplicity of wires, tubes, pipes, and small parts, avoid that car as you would the plague. Modern electrical devices are very highly perfected, they are reliable and efficient, and if they are good they are simple. The more wires the more troubles, as a rule, for despite the perfection of electrical devices about ninety per cent of all motor troubles are electrical, and nine times out of ten the troubles are in the wires. If possible, select a car with dual ignition system—battery and magneto—as, in that case, if one system fails you have the other. Be sure that you can easily obtain new parts at any time and in any large city, and be equally sure that you can find a service station for your electrical equipment when you need it. Don't get a car that lacks adequate lubricating devices, and be sure there is an oil or grease cup, or some means of efficient lubrication, at *every* bearing, joint, or moving part. Examine for take-up adjustments, especially on steering mechanism, fan belt, bearings, brake rods, and all other parts which are subject to wear. Don't select a car which depends upon guesswork for anything. See that there are gauges for fuel, oil, charging, and discharging batteries, and such things. A new motor should run quietly, and if there is any appreciable vibration, any rattle or noise, when the motor is idling, cross the car off your list; for with use, every rattle, noise, and vibration will rapidly increase. Be sure the car is equipped with detachable rims and with tires large enough to carry the

car's weight without undue strain. Every tire manufacturer or dealer can furnish you with tables showing the sizes of tires for various weights, and it is an easy matter to weigh the car. Be sure that the clutch is easy, that you don't have to exert all your strength to throw it out, and that it takes hold smoothly and evenly without jerking or jumping. Have the car demonstrated on the level, on hills, and on rough roads, and test for easy riding, quick get-away, easy gear shifting, quiet running, hill-climbing ability, grip of brakes, and ability to run slow on high gear.

Finally, see that the car is well finished, that the paint and varnish are good, that the top is well made and easily raised and closed, that the side curtains are satisfactory, that the car is well equipped with power pump, tools, extra rims, tires, etc.

Oftentimes the question arises as to whether it is best to buy a new or a used car. There is no question that many used cars are very great bargains, and that, for the same money, one may obtain a much better car from the used-car market than would be possible among new cars. But in order to purchase a used car to advantage one must know cars, must be well up in motor mechanics, and must be "from Missouri," for many of the dealers are utterly unprincipled, their so-called "guarantees" are not worth the paper they are written on and they are in business to do you or any one else. Of course, there *are* reliable and honest dealers in used cars, but they are mighty hard to find. If you decide to buy a used car, go to a dealer in new cars, an agent of a manufacturer who sells used cars taken in trade for new ones, and upon whom you can depend to the same extent, as if you were purchasing a new car. The only other way,

if you are not a car expert, is to hire or get some reliable, car-wise friend or mechanic to advise you, when making the rounds of the used-car dealers. Above all, beware of the used car resplendent in a new coat of paint and shiny varnish. Many a crack, break, and repair has been effectively concealed under a coat of paint. Don't take anything for granted in buying a used car. Don't believe anything the dealer tells you until you have verified it. Don't imagine he is robbing himself to give you a bargain, and be sure the car is not an accumulation of assembled junk with a standard exterior. Leave no detail unexamined, test the car thoroughly, and then, if everything seems all right and the dealer is willing to allow a week's trial, you may be reasonably certain of the car. But, most important of all, pick out a dealer known to be reliable, honest, and with a reputation to maintain.

THE MECHANISM OF THE MOTOR CAR

At first sight the mechanism of a motor car appears a very complicated affair, but in reality it is very simple. In fact, it is doubtful if there is any machine of equal efficiency and scope which has been so simplified as the modern automobile. Any one with intelligence can soon master the principles and operation of a motor car, and can make any adjustments and minor repairs which may be necessary. The first duty of every owner or driver of a car should be to familiarize himself, or herself, with its mechanism, its various parts, and their functions, until he or she feels competent to locate and remedy any ordinary troubles.

Many of the most important portions of a car are out of sight, and, as is usually the case, "out of sight is out of mind," and as a result little attention is given to anything until it goes wrong. But if you understand the important relationship between each and every portion of a car's mechanism, and bear in mind that some small and insignificant trouble or the failure of some minor part, such as a screw, bolt, or cotter pin may result in a fatal accident, and if you look after such matters as carefully as the outward appearance of your car, you will seldom have troubles and vexatious breakdowns, and your repair bills will shrink tremendously.

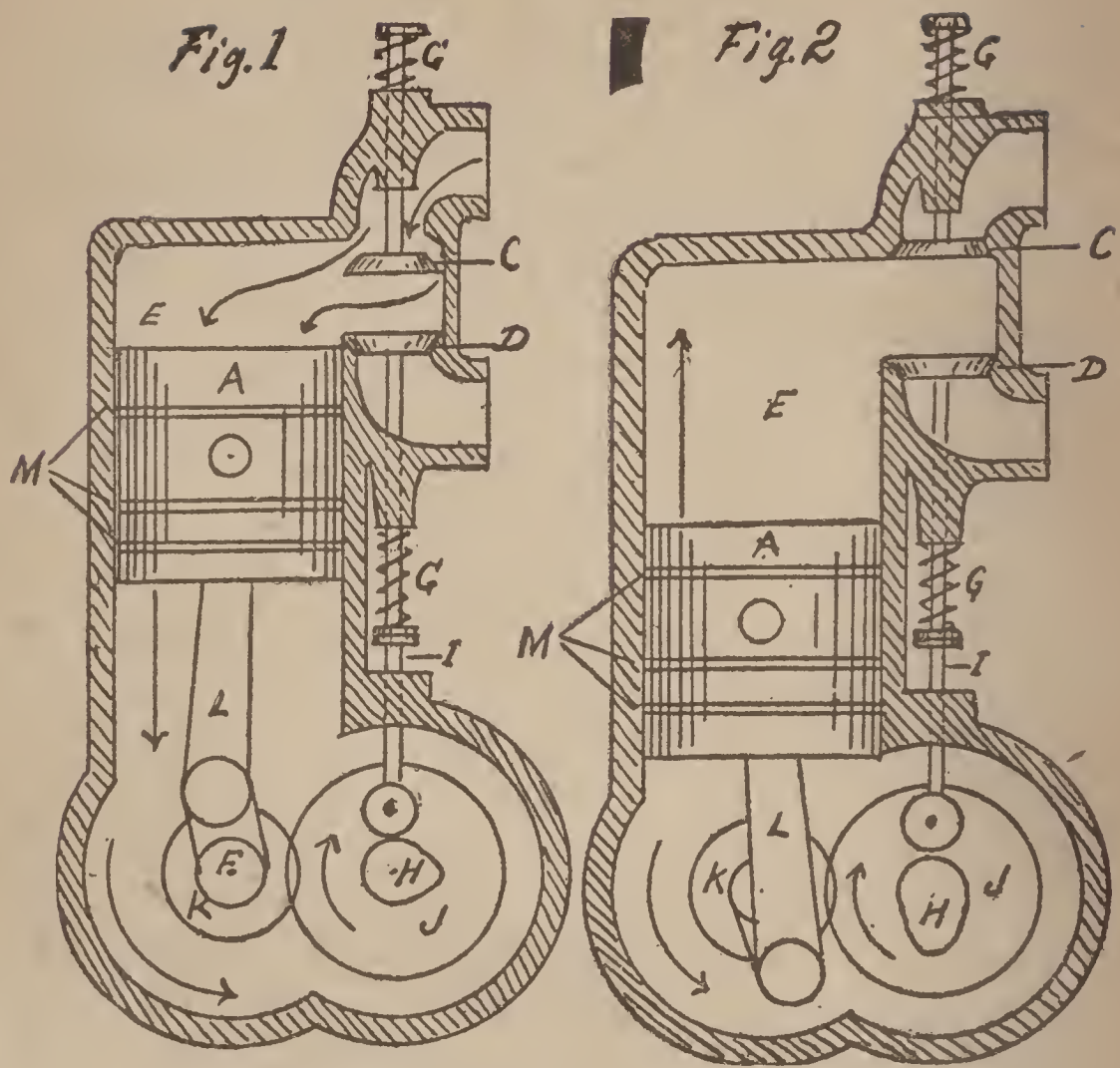
Broadly speaking, a motor car consists of the motor, the driving mechanism, the running gear, the chassis, and the body; but with the exception of the body and chassis these parts are made up of various units. Thus the driving mechanism includes the clutch, the transmission

gears, the universal, the propeller shaft, the differential, the axles, et cetera, with their various parts. The motor includes the cooling system, the fuel system, the electrical equipment, et cetera, while the running gear includes the wheels, springs, steering devices, et cetera, although strictly speaking the latter is partly included in the chassis.

Hence it is easier to consider each principal unit separately; and as the motor is the most important and most complicated unit of all, we will take it up first.

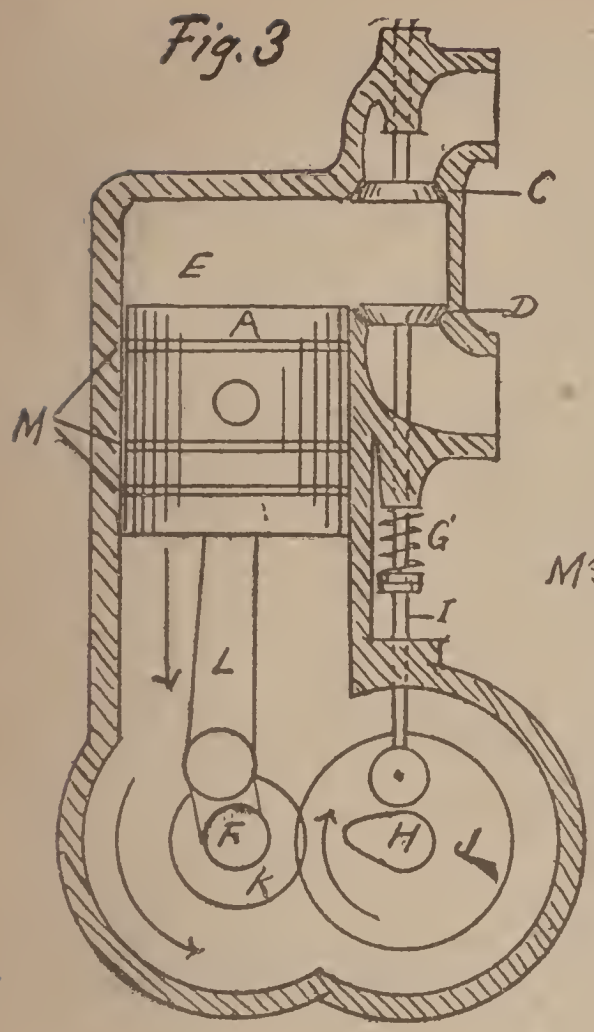
Primarily the motor consists of cylinder, piston, connecting rod, valves, and crank shaft, with the valve-operating mechanism consisting of cam shaft and cams, gears, et cetera.

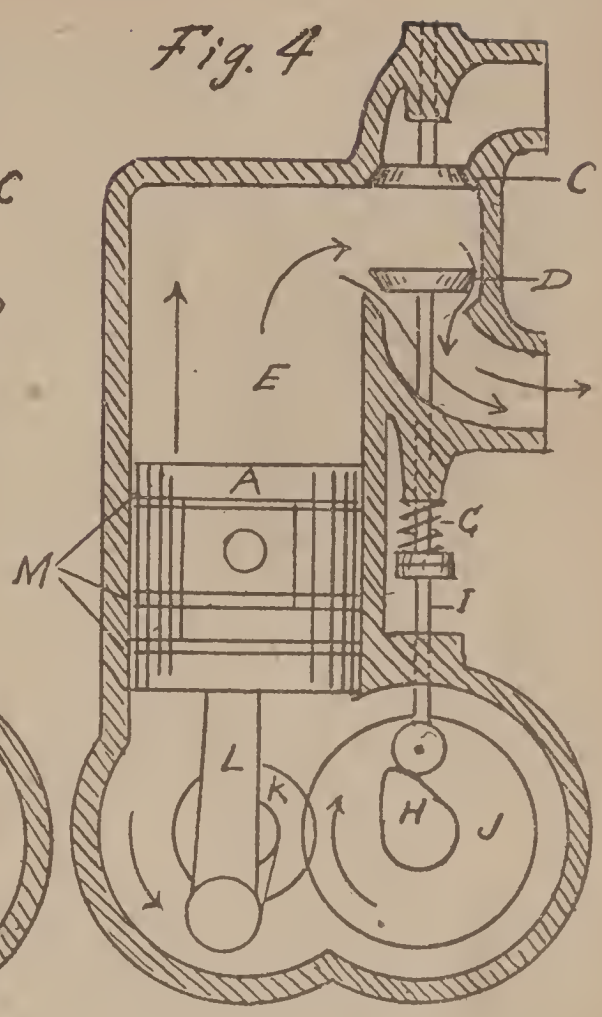
Before discussing the functions of the various parts and their relationship, it may be well briefly to explain the principle or operation of a gasoline motor. There are two principal forms or types of motors—the one known as the two-cycle or two-stroke motor, the other as the four-stroke or four-cycle motor; but as the former are seldom used in motor cars, I shall deal only with the four-cycle type. In this class of motor there is but one impulse or explosion to each two revolutions, or four strokes of the crank shaft in each cylinder, hence the name. By increasing the number of cylinders to four, an explosion is produced at each stroke, while by adding more cylinders more frequent explosive impulses are obtained. In every case, however, the principle of operation is precisely the same, and an explanation of what takes place in one cylinder will serve for all. In Plate I a diagrammatic section of a four-stroke, single-cylinder motor is shown. In *Fig. 1* the motor is shown with the *Piston, A,* at the top of the stroke, and ready to move downward. In this position the *Inlet Valve, C,* and the



FIGS. 1–4—Operation of four-stroke motor.

Exhaust Valve, D, are both closed, but as the piston commences to move downward the inlet valve is opened by means of the valve mechanism, thus allowing the fuel to be drawn into the *Cylinder, E,* by the suction exerted by the descending piston. At about the limit of the downward movement of the piston, as shown in *Fig. 2,* the inlet valve is closed, thus preventing the fuel charge from escaping, and the upward movement of the piston compresses the gas until the piston reaches the upward limit of its stroke, *Fig. 3,* when the gas is fired or exploded by an electric spark. The force of the explosion drives the piston down, thus giving an impulse to the





Crank Shaft, F. Then, when the limit of this downward stroke is reached, the exhaust valve, *D,* is opened by its mechanism, *H,* and the upward-moving piston forces the burned gases out through the opening under *D.* As the limit of this *fourth* stroke is reached, the motor assumes the position shown in *Fig. 1,* and is ready to draw in a fresh fuel charge as explained.

From this it will be seen that the single firing, or explosive, stroke is depended upon to complete two revolutions of the crank shaft, and that the momentum of the flywheel is all that carries the shaft around and completes the whole operation of the motor until another impulse occurs. The four strokes of this motor are

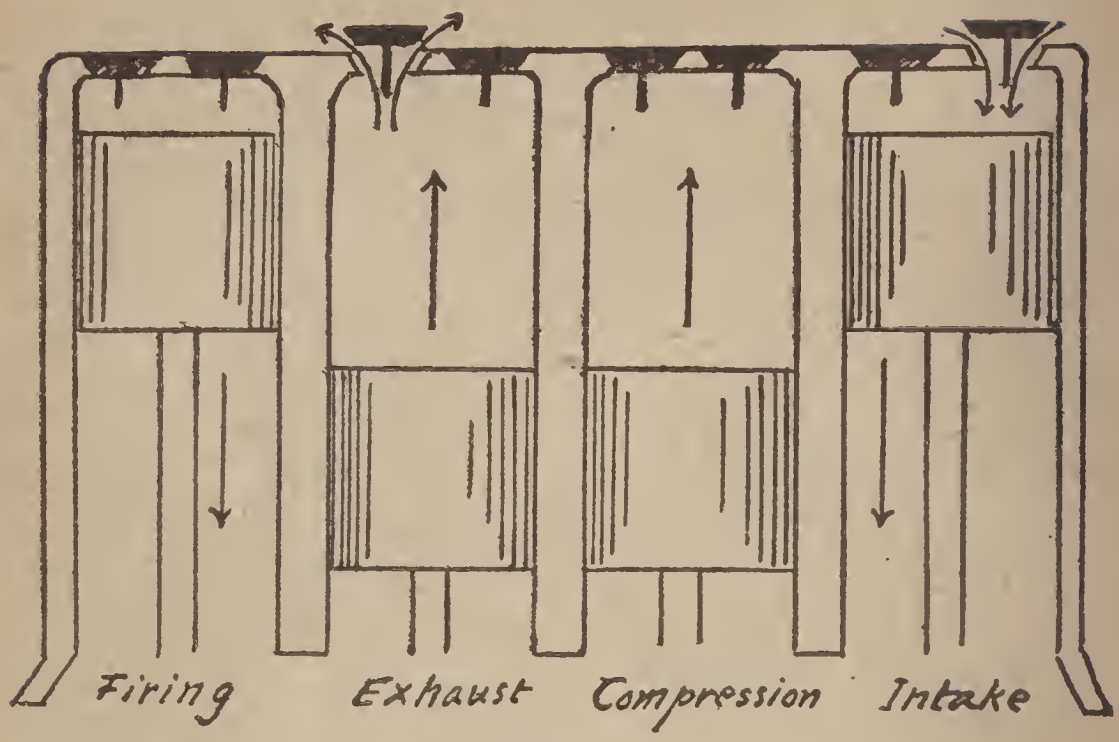


Fig. 5

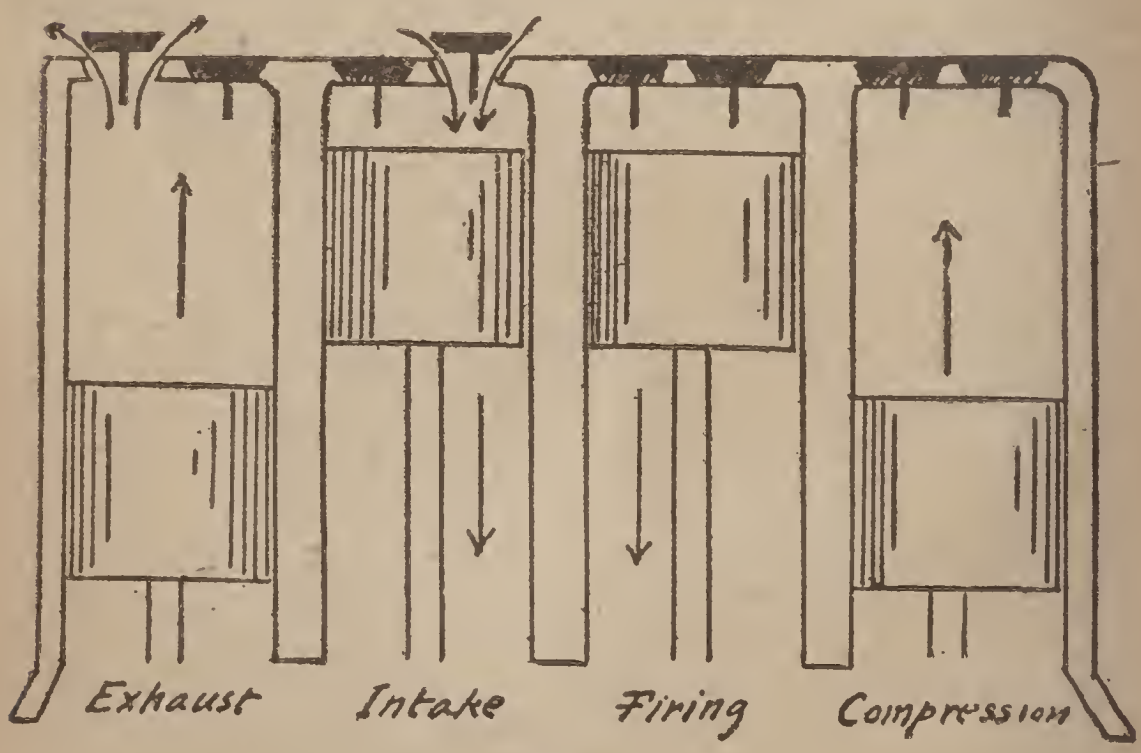


Fig. 6

FIGS. 5–8—Four-cylinder firing.

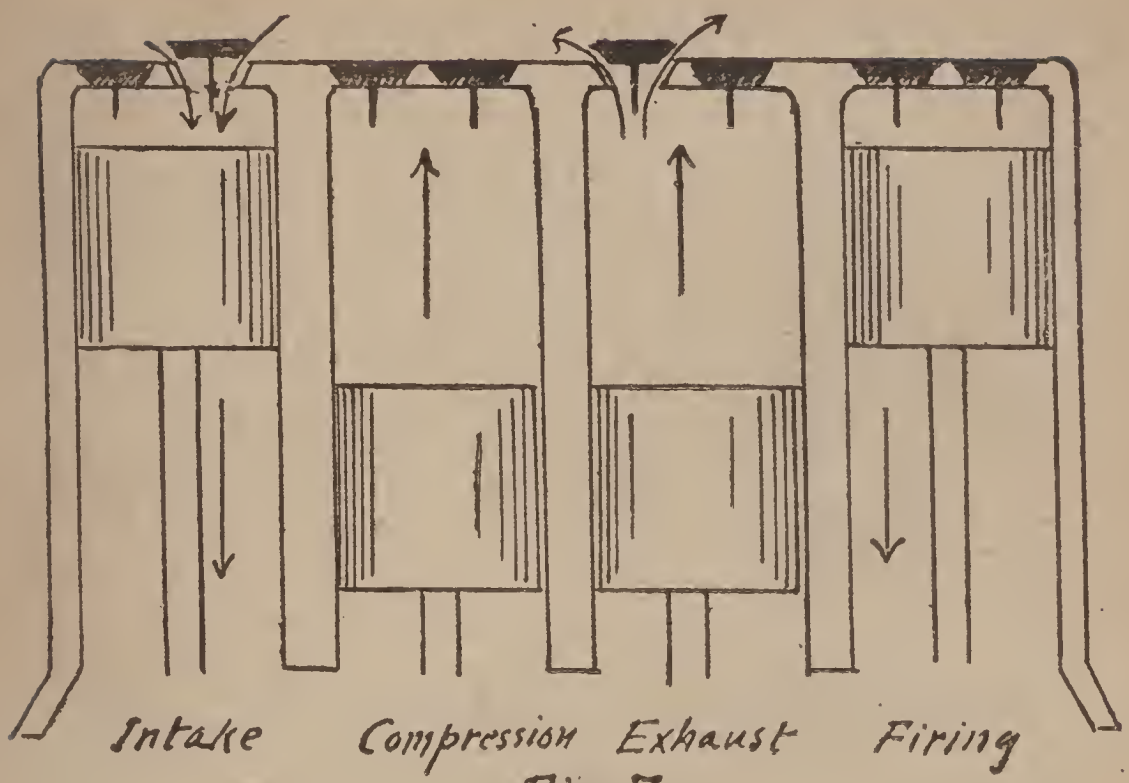

Intake
Compression
Exhaust
Firing

Fig. 7

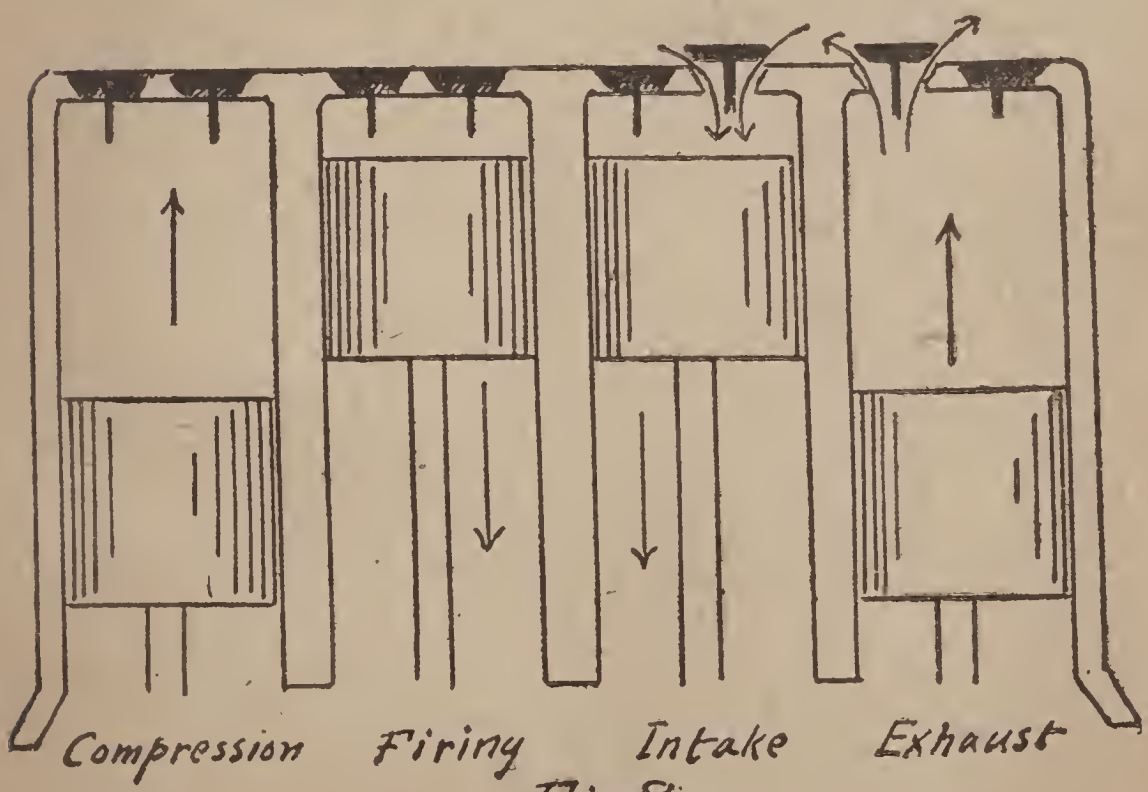

Compression
Firing
Intake
Exhaust

Fig. 8

known as THE INTAKE STROKE, *Fig. 1;* THE COMPRESSION STROKE, *Fig. 2;* THE FIRING STROKE, *Fig. 3;* and THE EXHAUST STROKE, *Fig. 4.* It is to avoid the jerky, irregular operation which would occur, to overcome the necessity of a heavy flywheel to carry the motor through its cycle, and to provide a more even torque or force on the crank shaft, as well as to produce more power without proportionately increasing the size and weight of the parts, that multiple-cylinder engines are used. Thus, in the case of a four-cylinder motor, there is an explosion at every stroke, for one cylinder will be firing while another is exhausting, another is compressing, and another is drawing in a charge of gas, as will be more easily understood by referring to *Figs. 5, 6, 7, 8.* By using eight cylinders, an impulse occurs at every *half stroke,* or four impulses to every revolution of the crank shaft, while a six-cylinder motor gives *three* impulses to each revolution (*Fig. 9*).

Now, having grasped the principles of operation of a four-stroke motor, let us study the various parts, their functions, their relationships, and their principles of operation.

Aside from the *Cylinder, E, Piston, A,* the *Piston Rings, M,* the *Connecting Rod, L,* and the *Crank Shaft, F,* which are common to all motors, and vary only slightly in design or type, there are the *Inlet Valve, C,* the *Exhaust Valve, D,* the *Push Rods, I, Valve Springs, G, G,* the *Cam, H,* the *Cam Gear, J,* and the *Driving Gear, K.* But in their valve mechanism there is a great difference in different motors. The commonest form or type has valves of the style illustrated in the diagrams, and which are known as *"Tappet"* or *"poppet" valves,* but the Knight motors have a very different valve system, con-

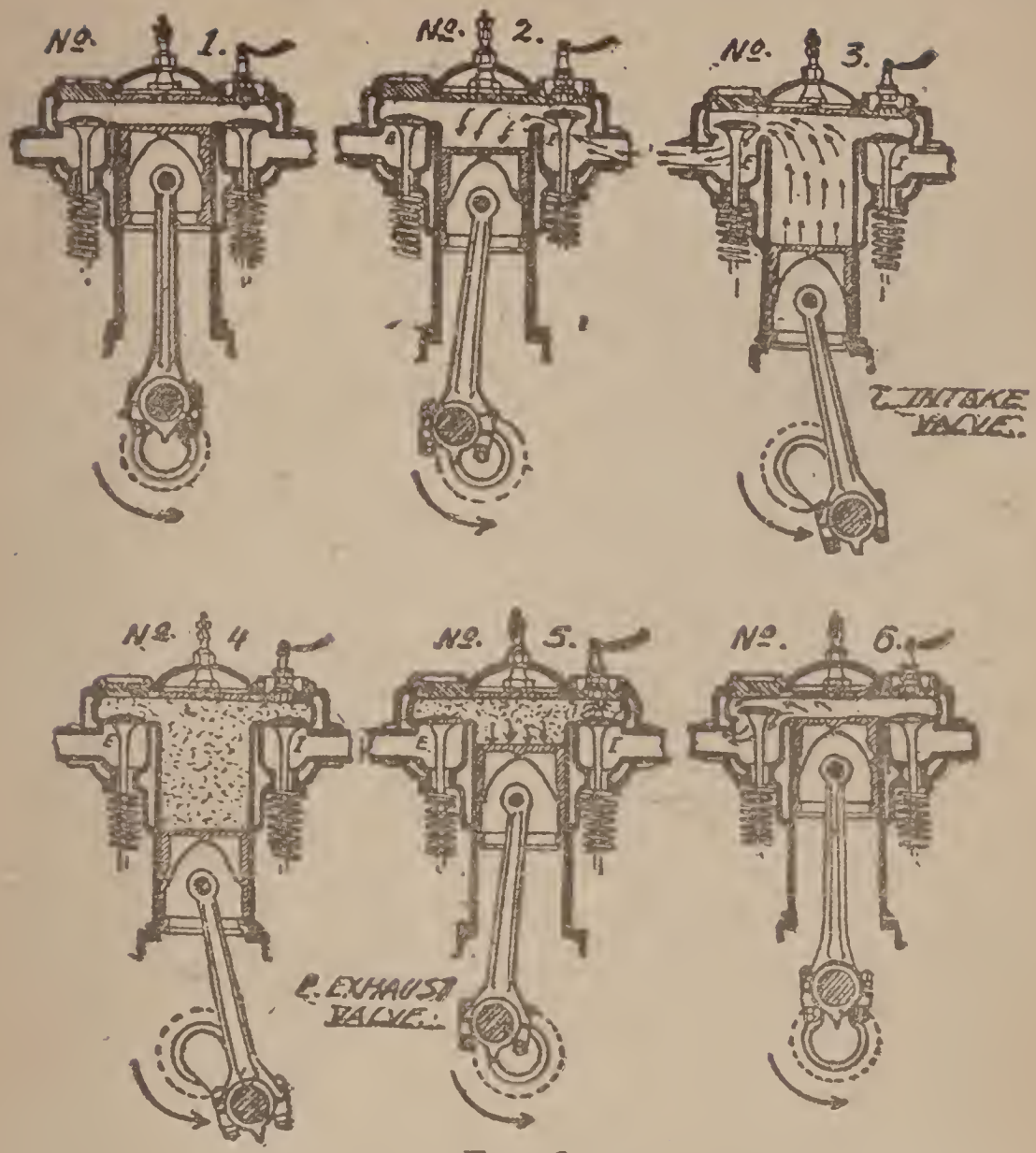


Fig. 9

FIG. 9—Six-cylinder firing.

sisting of sliding sleeves, as shown diagrammatically in *Fig. 10.* Even motors equipped with tappet valves vary greatly in their valve-operating devices, and they may be operated directly from the cams, as in *Figs. 1-4,* or they may have overhead valves operated by rocker arms; while still other motors may have one set of valves of the overhead type, and the others of the direct or "L-head" type.

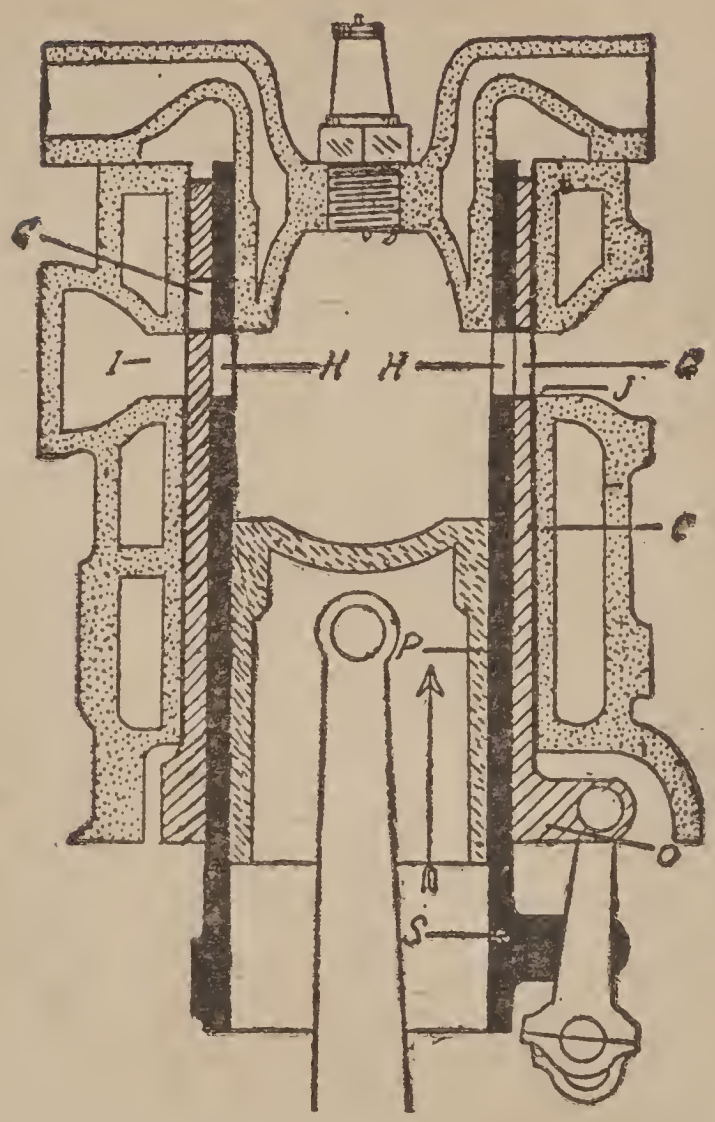


Fig. 10

FIG. 10—Knight motor-valve system.

The valve gears may also be of any one of many types, but they are always proportioned so that the large or valve gear, *J*, makes one revolution to every two revolutions of the crank shaft and gear, *F, K;* and, moreover, the gears must be very carefully set so that they will open and close the valves at exactly the right time in relation to the stroke of the piston.

The *Piston Rings, M*, are very important parts of the motor, for upon them depends the compression of the

gas, and much of the power and successful operation of the motor. They consist of cast-iron rings, open at one side, and fitting snugly into grooves in the piston. They are eccentric, or thicker on one side than the other, and are set on the piston so that the joints or openings do not come in line. When in position, in the cylinder, they press firmly against the cylinder walls, thus preventing the gas from leaking between the piston and cylinder, and at the same time allowing the piston to move freely in the cylinder without binding. Any leakage past these rings will decrease the power of the motor, and so it is very necessary to keep the rings well oiled, free from carbon, and tightly fitting. In addition to these essential parts of a motor, there must be devices for lubricating the various moving parts, for vaporizing and feeding the liquid fuel to form a gas, to ignite or fire the charge of fuel at the proper instant, and to keep the motor cool and at an even temperature. There are various systems of lubricating, but in nearly every case they are very simple, consisting of an oil pump which forces the oil in the crank case to the various parts requiring lubrication, and which, in the best motor cars, are provided with a gauge which shows whether or not a sufficient amount of oil is being fed. The cooling systems employed on motor cars are of two general types, the air cooled and water cooled. Only a very few cars are air cooled, the Franklin being the best known; and as no attention is required in this system, and the only mechanism is the fan, it is not necessary to discuss it. The water-cooling system is the one in ordinary use, and there are two types of this system—one known as the *thermo-siphon* system, the other as the *forced circulation.* In both types there is a radiator which serves to cool the heated water from

the water jackets about the motor's cylinders, and which is connected near the bottom and near the top with the water jackets. In the *forced-circulation* type, the water is forced around the cylinders, and is kept in circulation by means of a rotary pump, while in the *thermo-siphon* system circulation depends upon the principle that heated water rises and cold water sinks. Thus the heated water from the cylinder jackets is constantly being pushed up and into the top of the radiator by the water which, cooled by radiation, sinks to the bottom of the radiator, and enters the jackets at their bases. But even when equipped with a radiator and with water constantly circulating around the cylinders, a motor will soon become overheated, and in order to maintain the water in the radiator at a uniform temperature, a revolving fan must be provided for the purpose of forcing a constant current of air through the radiator. As the efficiency of the cooling system depends upon a free and constant circulation of both air and water, it is highly important to keep pumps, fans, radidators, pipes, and all other parts of the system in perfect condition, for nothing injures a motor more than overheating.

The apparatus designed to vaporize and feed the fuel to the motor is known as the carburetor, and, while there are many designs and types in use, the principles of all are identical, and an explanation of one of the simpler types will serve as an example for all. The essential parts of a float-feed carburetor, such as are used on motor vehicles, are shown in the diagram, *Fig. 11,* and consist of a chamber or bowl, *B,* which contains the liquid fuel, which enters through the *Inlet Pipe, G;* the *Float, F,* which operates the *Float Valve, H,* and regulates the flow of gasoline and maintains it at a constant level; the

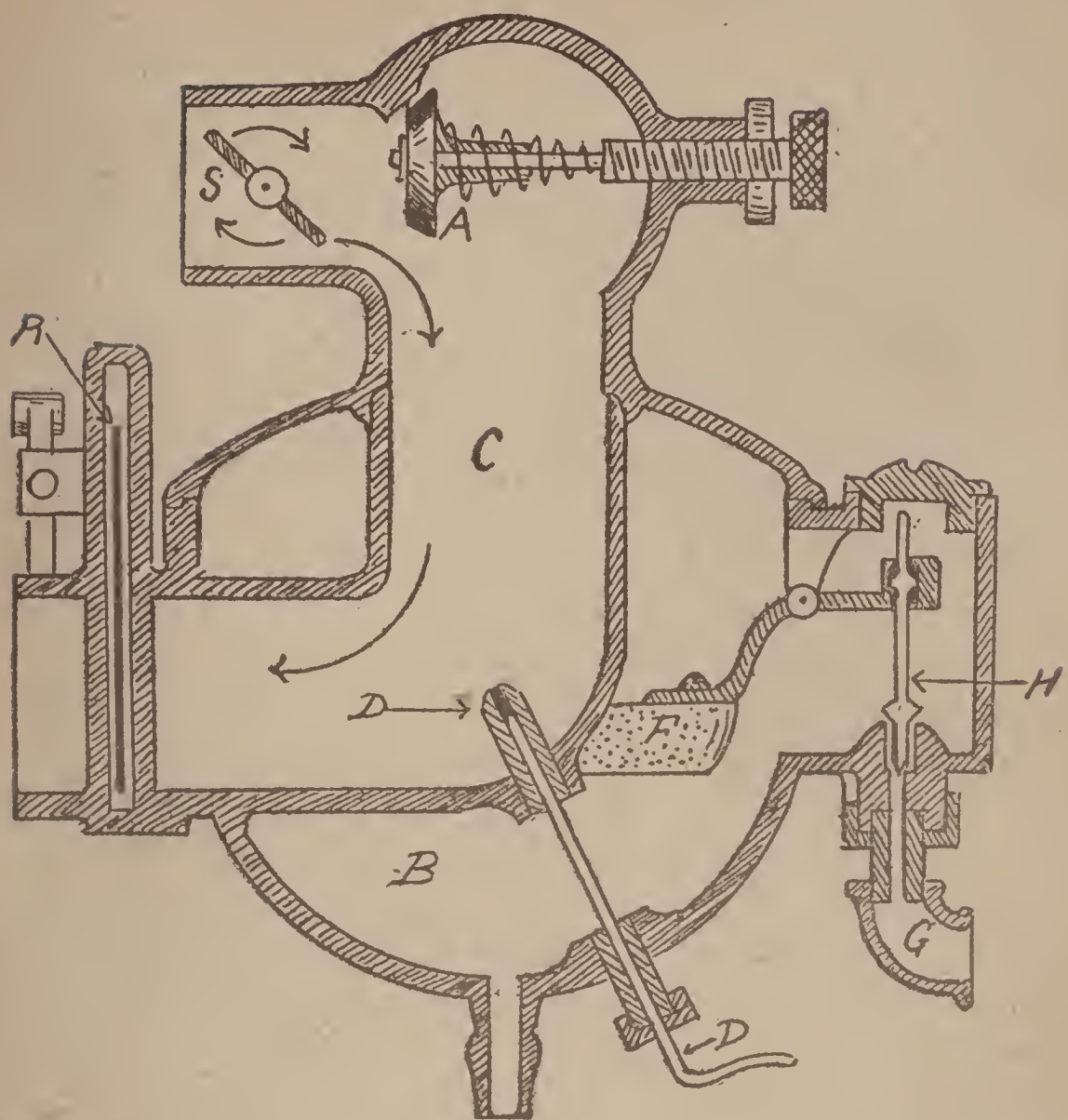


Fig. 11

FIG. 11—Float-feed carburetor.

Needle Valve, D, by which the amount of fuel fed to the motor is controlled; the *Venturi Tube, C,* through which air is drawn to vaporize the liquid fuel before it is drawn into the cylinder, and the *Air Valve, A,* by which the proportions of air and liquid may be adjusted. The operation of such a carburetor is extremely simple, notwithstanding that the average automobile owner looks upon the carburetor as a strange and mystical device beyond all com-

prehension. When the fuel is turned on, it enters the bowl or float chamber until the float, rising with the liquid, closes the float valve, *H*, and shuts off the supply. As long as the motor is not in operation, the fuel in the chamber remains at the same level; but as soon as any fuel is drawn into the motor, the float drops and opens the valve, thus allowing more fuel to enter and keep the bowl filled. As the piston moves on the intake or suction stroke, a current of air is drawn through the tube, *C*, and past the needle valve, *D*, to the inlet valve of the motor.

This inrushing air draws a small portion of the liquid fuel from the needle valve and vaporizes it to form a gas, which is fired or exploded in the cylinder. As the motor's speed increases, a stronger current of air is produced, and more fuel is drawn into the cylinder with it, and if the air opening remained constant this would soon result in an excess of fuel being used, and a gas would be formed which would be too rich or "wet" to produce the full power of the motor or even to explode at all. To prevent this, an air valve, *A*, is used, and is kept pressed against its seat by a spring which may be adjusted to varying degrees of tension. With the increase of the suction of air, this valve is drawn back, thus permitting more air to enter, and in this way the proportions of air and liquid fuel are maintained automatically; for it is possible to obtain any proportion of gasoline to air by loosening or tightening the air-valve spring or by opening or closing the needle valve. In some carburetors there are two or more needle valves or jets, so arranged that one feeds fuel when the motor is running slowly, while the others furnish supplementary fuel as the speed increases. Other types of carburetors have supple-

mentary air intakes, while still others depend upon balls resting on openings for regulating the amount of air, the increased suction lifting the balls and permitting more air to enter. Still others have no needle-valve adjustment, the proportion of fuel being entirely regulated by the air valve; but in every case the principle is the same. In addition, nearly all carburetors are provided with a *Throttle, R,* which permits more or less gas to enter the cylinders, and by which the speed and power of the motor is largely controlled. In most cases, too, a *Choke* is provided, *S,* by which the air may be shut off, thus producing a very rich mixture for starting the motor.

The means by which the charge of gas is fired or exploded in the cylinders is known as the *Ignition System,* and this varies in its details with various motors, although in principle it is the same in all motors. In its simplest form the ignition system consists of some device—either a magneto or battery—for producing an electrical current; an apparatus for producing a hot electrical spark within the cylinder, and mechanism designed to control the flow of electricity and produce the spark at the proper instant and in the proper relation to the movement of the piston.

Many cars use magnetos exclusively for ignition; others use batteries only; and still others possess a dual system by which either a magneto or battery may be used. There are two classes of magnetos, known as high and low tension, and the principle and operation of each is very distinct. The simplest form of ignition is probably the high-tension magneto, for with this system the number of wires and parts is reduced to the minimum. The magneto consists primarily of a *Magnet, Fig. 12, A,* within the arms of which is a revolving device known as

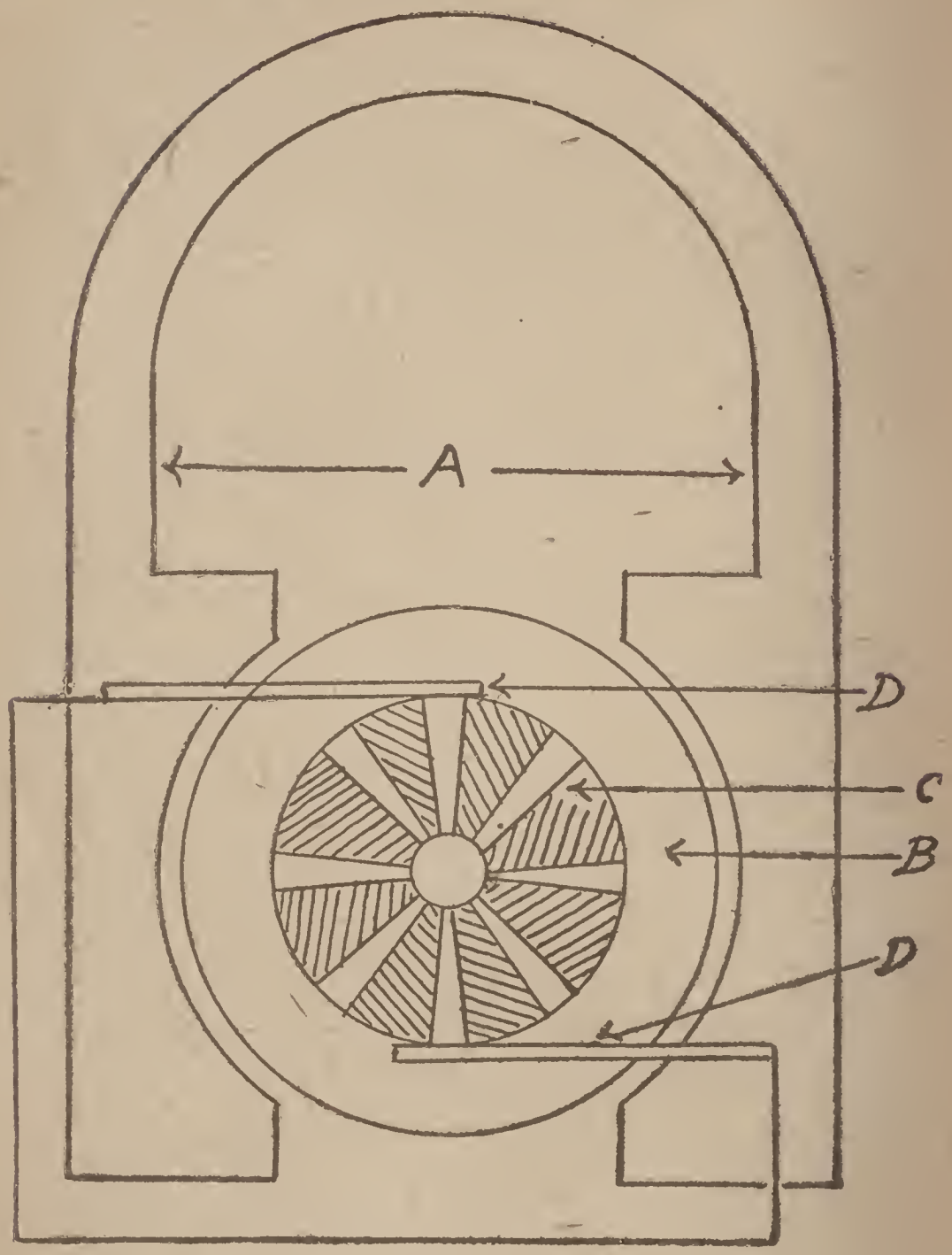


Fig. 12

FIG. 12—Magneto.

an *Armature, B,* and which, rotating in the magnetic field, produces a current of electricity which is gathered up and distributed by means of a segmented piece of copper known as a *Commutator, C,* and bits of metal or carbon

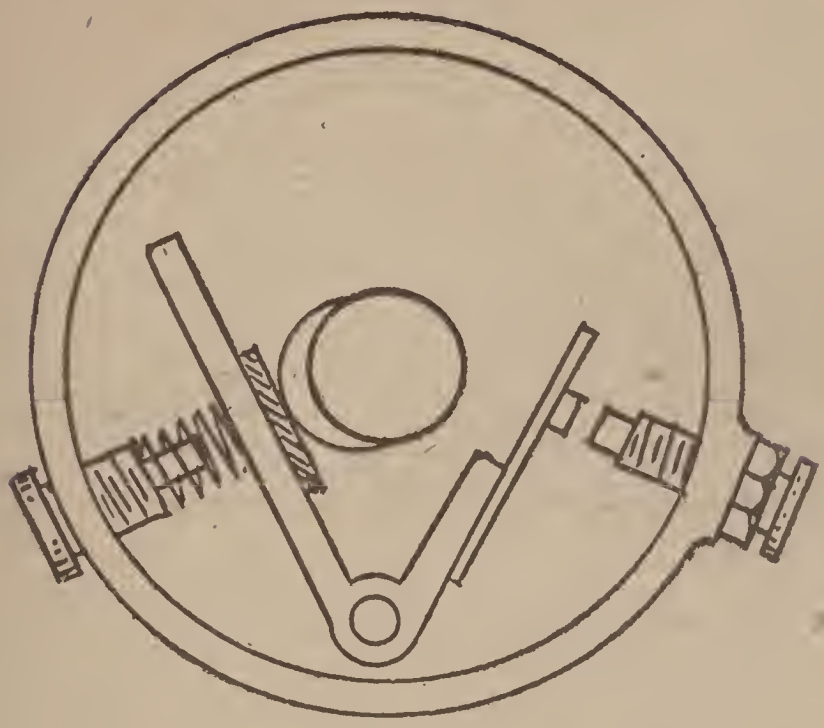


Fig. 13

FIG. 13—Breaker.

called *Brushes, D.* In addition there is a *Breaker, Fig. 13,* which interrupts the current and allows it to flow through the wires to the spark plugs at the proper instant; and in each case there are brushes of some sort for distributing the current to the proper plugs in the motor. Some makes of magneto have a commutator which passes over stationary brushes; others have a single brush and a separate mechanical distributor; while still others have a stationary winding or armature, while the magnets revolve and the current passes through a coil without a breaker. As a rule, each magneto requires special care and adjustments, and it is far wiser to secure a detailed explanation of the magneto and directions for its care, use, and adjustments from the manufacturer, than to attempt to master all the various types of these instruments. Moreover, magnetos give little trouble, and if they are kept dry and clean they seldom require any at-

tention save an occasional adjustment of the breaker or the removal or cleansing of brushes.

In the low-tension type of magneto, the current, instead of being passed directly to the spark plugs, is led through a coil, which increases the intensity of the current through a distributing device known as a *timer* or a *distributor.* When batteries are used, either storage or dry, the coil and distributor are also employed; but in every case, whether battery, high-tension, or low-tension magnetos are used, the spark is produced in the cylinder by means of a spark plug, and, as much of the power and efficiency of a motor depends upon a hot, intense spark being produced at the proper instant, it is most important to have the entire electrical equipment in perfect condition, and especially to have the spark plugs clean and properly adjusted.

The transmission, or driving mechanism, of a car consists of a clutch; the transmission gears, also known as the gear set; the universal joint; and the differential, with the various shafts, bearings, gears, controls, et cetera, which belong to them.

The clutch is a device for connecting or disconnecting the motor from the driving mechanism at will; and, while there are several types of clutches in use, their principle and functions are the same in all cases. The leather-faced clutch consists of a conical ring or disk faced with leather, and which fits within the hollow of the *Flywheel, Fig. 14.* The leather face, *B,* is pressed tightly against the inner surface of the flywheel by a stiff spring, *C,* and by the friction thus obtained the power of the motor is transmitted to the driving mechanism of the car. Behind the cone, and connected to it, is a device, *D,* connected

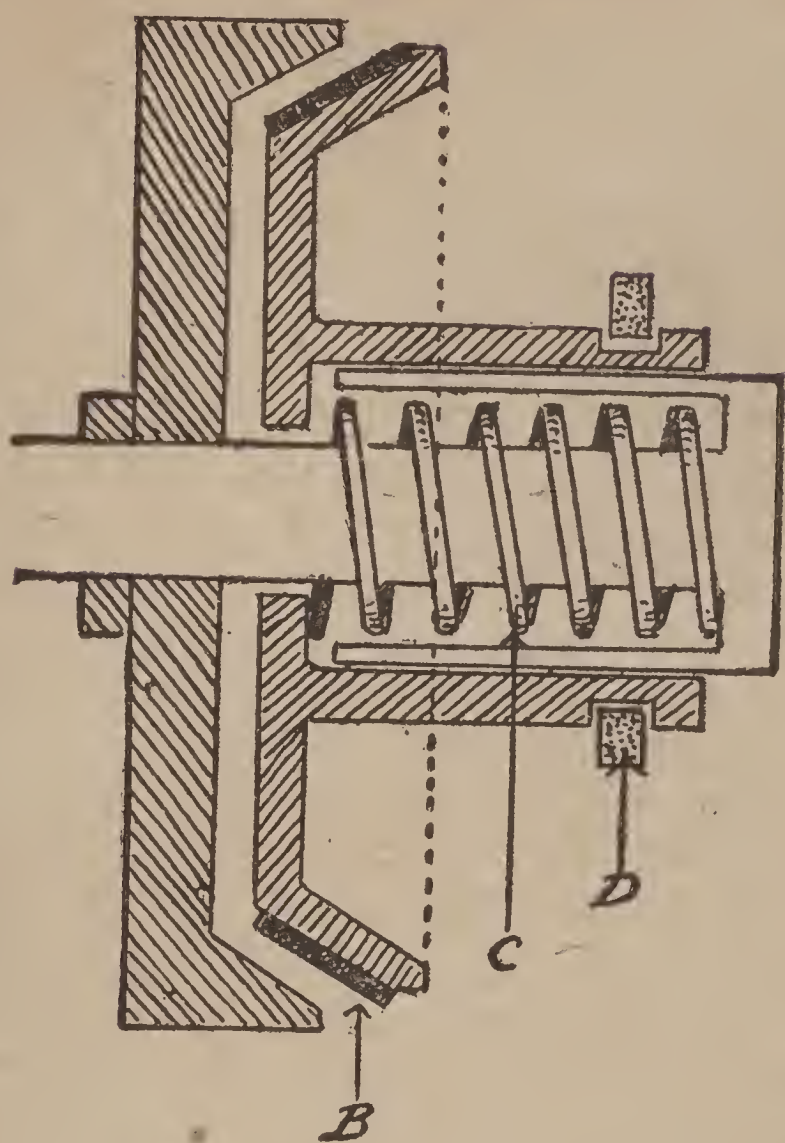


Fig. 14

FIG. 14—Leather-faced clutch.

to a foot pedal, and by which the clutch may be drawn back or thrown out, thus allowing the motor flywheel to revolve while the clutch remains stationary. Another type of clutch, known as the *Disk Clutch,* operates on the same general principle, but instead of having a leather-faced cone fitting in the flywheel the disk clutch consists of a number of metal plates keyed alternately to the motor shaft and clutch casing and which are held

pressed together by a strong spring which may be released by a foot pedal.

The function of any clutch is to enable the transmission gears to be shifted from one speed to another, or from neutral into a speed or vice versa, as well as to release the driving power of the motor in case of emergency. It will be easily understood that if the motor were attached permanently to the driving mechanism it would be impossible to operate the motor without moving the car, and that, even with gears which could be thrown out or into mesh, it would be impossible to shift the gears while they were revolving and carrying a load. Hence the clutch is a very important part of the car, and, although hidden away and seldom seen, yet it is worthy of the same care and attention as any other essential portion of the machine.

Back of the clutch, and usually close to it—sometimes attached to the rear axle—is the *Gear Set,* or transmission gears. There are many types of gear sets in use, but all are similar in principle, and the commonest is the three-speed-selective type. In this form of gear shift there are three forward and a reverse speed, as well as a neutral position, and the various speeds or movements are obtained by sliding the gears in or out of mesh by means of a lever or handle, which operates either in an H-shaped slot or on a ball-and-socket connection. It is not necessary to enter into a minute or detailed explanation of the gears or their arrangement, except to say that by moving a large gear on the propeller shaft into mesh with a small gear on the motor or driving shaft, the first or low speed is obtained, and by which the power of the motor delivered at the rear axle is increased. By moving this large gear out of mesh and substituting another, the second

or intermediate speed is obtained, while by another movement of the lever the gears are thrown out of mesh and the driving and propeller shafts are locked together, thus obtaining direct or third speed. The reverse motion is obtained by moving the gears to mesh with a separate gear on another shaft, while by throwing the lever into neutral position all gears are out of mesh and the driving shaft is free to revolve independently of the propeller shaft. Some gears have a fourth forward speed, but their principle is the same. The exact positions of the lever to obtain the various speeds are not always the same in all cars, although what is known as the standard gear shift is the most common. In this type of gear shift, pulling the lever to the left and back gives the first speed; to the left and forward, reverse; to the right and forward, second; and to the right and back, third or direct. It makes little difference whether a lever with a slotted plate or the cane-handle type with ball-and-socket joint is used, for the motions are similar in each case, and by moving the lever to one side or the other and pushing it forward or pulling it backward the gears are shifted as desired. Moreover, if one speed is known, all the others come easily, for reverse and low are always on one side at opposite ends of one throw, and second and third are at the opposite ends of throw on the other side. Thus, if low is left and back, reverse will be left and forward, second will be right and forward, and third will be right and back.

The interior of the gear case is a sealed book to most motor-car owners, and if the gears are kept properly lubricated by keeping the gear case packed with grease, and if gear shifting is done intelligently and carefully, there is no reason why the case should ever be opened

until the gears and bearings need to be replaced through long usage and normal wear.

Somewhere between the clutch and the rear axle, and usually back of the gear case, is the *Universal Joint,* a flexible connection between the rigidly fixed motor or gear shafts and the propeller shaft, and so designed as to permit movement in any direction, while at the same time transmitting the power and motion from the motor to the wheels. Many different forms of universals are in use; but the purpose of every one is to permit the wheels and rear axle to jump or swing with the inequalities of the road and the elasticity of the springs, without bringing a strain on the driving mechanism. As a rule, universal joints require little attention except greasing; but they should be adjusted for wear as required, and should always be kept covered with a leather boot to prevent dust and mud from getting into the joints and cutting the bearings.

The shaft which connects the universal with the rear axle is known as the propeller shaft, and, as it is incased in a tight sleeve or tube with its bearings, it seldom requires any attention except lubrication.

At its rear end, the propeller shaft is connected to the axle by means of a device known as the *Differential.* As the principles and purpose of the differential is often a great puzzle to motor-car owners, a short explanation is necessary. When an automobile is turned around, one of the rear wheels must travel much farther than the other, and consequently it must revolve faster *(Fig. 15).* If both wheels were fixed immovably to the same axle, one wheel would drag or slip, thus producing a great deal of friction and strain and making turning next to impossible. If the axle with the two wheels fixed to it was

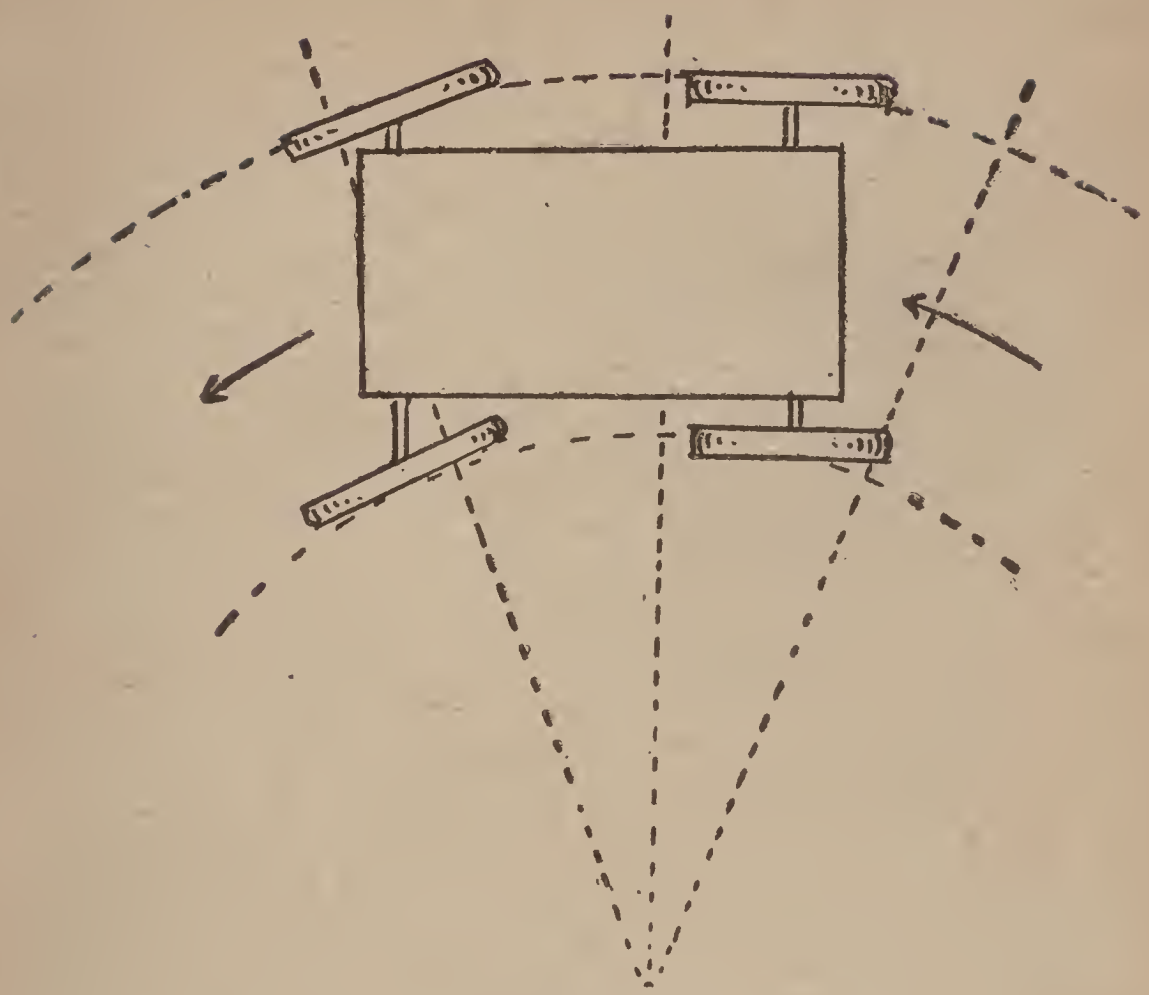


Fig. 15

FIG. 15—Wheels in turning a corner.

driven by power, turning would be even more difficult, and the vehicle would either be slued about or upset or else something would have to break. It is to overcome this and to distribute the power equally to both wheels that the differential is used. There are various types of differentials, some constructed with spur gears, others with bevel gears, others with skew gears, and others with worm gears; but in principle they are all alike. All consist of gears or pinions placed between the inner ends of the axles, meshed and keyed in such a way that either axle may revolve independently of the other; or one can remain stationary while the other revolves. Thus, if a

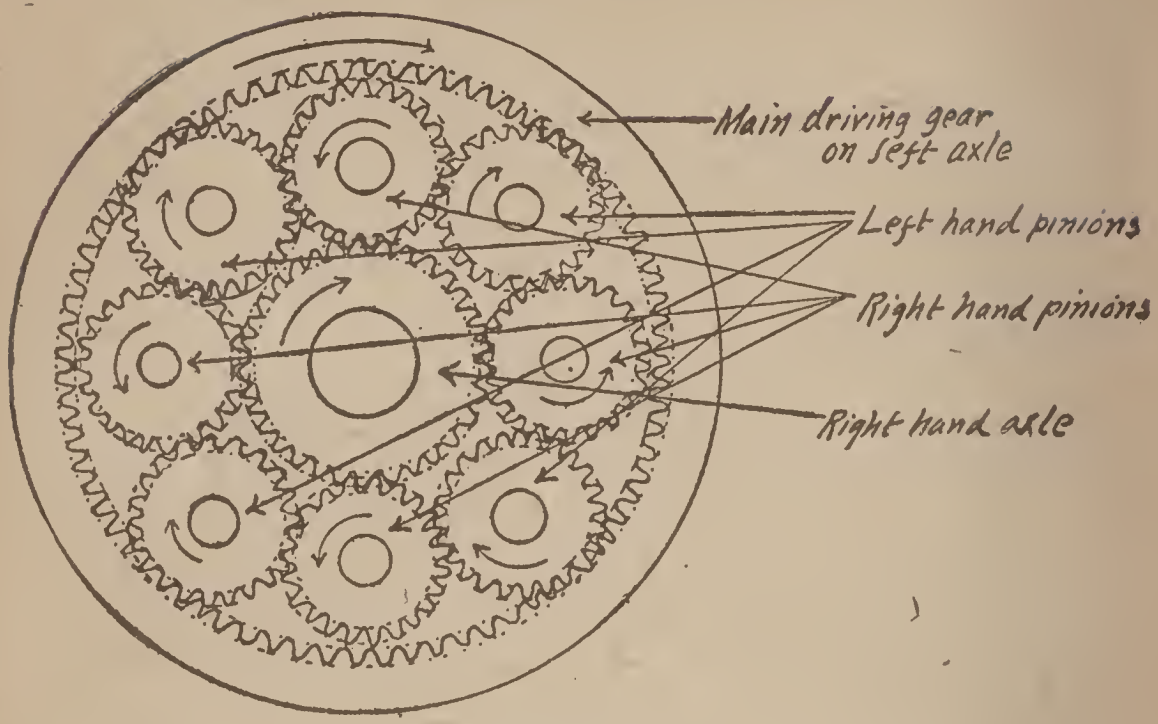


Fig. 16

FIG. 16—Differential.

right-hand wheel is held immovably, the power is transmitted to the left-hand axle, and the pinions or gears on the right-hand side merely turn around on the internal gear, as shown in *Fig. 16.* By such an arrangement, the two wheels drive equally when the car is running in a straight line; but as soon as a turn is made, the differential automatically distributes the power in proportion to the resistance offered by the wheels and the speed and distance which they travel. As the differential is inclosed in a tight case, and nothing is visible from the outside, this important part of the car's mechanism is often neglected. Every care should be taken to see that the differential case is kept well filled with grease, for undue wear or friction of these gears will result in jerky, irregular running, rapid wear of tires, and a strain on all the driving mechanism. Moreover, the bearings of the rear axle are lubricated from the grease in the differential, and

unless attention is given to this matter very serious results will follow.

The bearings of a car are a most essential feature of the whole, and they are an excellent example of the "out-of-sight-out-of-mind" parts. In addition to the motor bearings and the bearings of the gears in the gear shift, there are bearings in the clutch, in the universal, in the propeller shaft, in the differential, on both ends of the rear axles, and in the hubs of the front wheels, not to mention the fan bearings, the bearings in the steering mechanism, and a dozen or more other small bearings; for wherever there is a moving part, a bearing of some sort must be provided. The purpose of any bearing is to permit free motion and reduce friction, and in any motor car there are a number of different types of bearings used. Broadly speaking, there are but three classes of bearings—*Plain Bearings, Ball Bearings,* and *Roller Bearings;* but each class embodies many different types and designs, and each is used where its own particular advantages best suit it for the purpose. A plain bearing is the simplest of all types, for it consists merely of a piece of metal fitting closely about a revolving shaft, and the design used, as well as the metal employed, depends largely upon the speed and load of the shaft which it supports. A great many bearings are made of brass or bronze, while others are made of a composition known as Babbitt metal. In every case a lubricant of some sort must be present between the bearing and the revolving shaft, or else great friction will result, the bearings will heat up and seize, and will be scored, cut, or melted.

Many people seem to think that a bearing must fit tightly around a shaft, and that the bearing metal itself

forms the bearing surface and reduces friction. This is a great mistake, for the elimination of friction is obtained by a thin film of oil or similar material between the bearing metal and the shaft, and if the bearing is set up too tightly there will be no space for the film of oil, or else it will be so thin as to be useless. Ball and roller bearings are very different from plain bearings in principle and design. The former consists of a number of steel balls arranged in a disk or ring and known as a *Cage,* and which bear upon a smooth plate, cone, or cylinder of hardened steel. Roller bearings differ from ball bearings inasmuch as they are provided with steel rollers instead of balls. Ball and roller bearings reduce friction to a minimum, owing to the fact that only an infinitesimal point, in the case of the ball, or a minute line along the axis of a roller, touches the revolving shaft it supports; and, as the balls or rollers revolve freely in their cages, the result is the same as if the moving part had a great number of tiny bearings instead of one large bearing. But oil or lubrication is just as important in a ball or roller bearing as in a plain bearing, while, to prevent undue wear and friction, they must be kept carefully adjusted. If too tight, the balls or rollers will bind, heat, and cut in the same way as a plain bearing; and if too loose, the load will come on the balls or rollers unequally, some will be worn faster than the others, they will jam and break, and a ruined bearing or more serious trouble will soon result. Of all the bearings on a car, those which are called upon to do the hardest work and support the greatest load are the rear-axle bearings, and as a rule these are the very ones which are given least attention and care. But modern bearings are so well made and so perfectly adapted to their use that with ordinary

attention and an occasional adjustment they seldom give trouble. The main thing is to be sure they are always properly lubricated, and at the first squeak, grind, or other symptom of friction they should be examined and the trouble remedied.

Rear axles are of two principal types, and known as *Full Floating Axles* and *Semifloating Axles.* In the former, the outer bearings are between the hub of the wheel and the axle casing, and the axle itself carries no weight, its only work being to transmit motion to the wheels. In the other type, the axles support the weight, or a portion of the weight, of the car, as well as transmitting the power, and hence the full-floating type is preferable and more widely used. But in either case, if the bearings are kept in good shape and the car is not abused, there is little chance of axle trouble, although the best axles will at times break without any apparent reason.

Connecting the axles with the chassis, or frame, of the car are the springs, much abused, seldom cared for, and yet most important units in the efficiency, life, comfort, and economy of the car. There are many types of springs, but the purpose of all is to absorb or take up the vibration and jars caused by uneven road surfaces. They are not provided solely for the ease and comfort of the passengers, as some owners seem to think, but are designed also to give ease and comfort to the motor and the rest of the car's mechanism, and hence they should be cared for and kept in good condition at all times. Much of the elasticity, or resiliency, of a spring depends upon its various sections, or leaves, moving readily on one another. If a spring is dry, rusty, or dirty, there is an immense amount of friction between the leaves, and as a result the car receives jars, jolts, and vibrations which

would be eliminated if the leaves were kept lubricated. There are many devices on the market for this purpose, and a number of cars are equipped with them. But if your car is not, it is an easy matter to have them inserted in the springs, while just as good results may be obtained by oiling the springs from time to time. At the ends of the springs there are pins or bolts passing through bushings, or bearings, and these should also be kept lubricated. Most cars are provided with grease cups for this purpose, and they should always be kept well filled. Then there are the brakes, which also require a certain amount of attention, for your life and the lives of others will often depend upon the brakes being in good condition. There are usually two sets of brakes, *Internal Expanding Brakes* and *External Contracting Brakes,* and sometimes one set is the service brake and sometimes the other. Brakes should not be tight enough to drag or bind. They should not be so loose that they slip when applied, and care should be taken that the bearings, or pivots, and the joints of all brake rods and connections are kept clean and well oiled.

A very important and essential part of the car's mechanism is the steering gear, and, as any failure or derangement of the steering gear is likely to result in a serious accident, too much attention cannot be paid to it.

Most modern cars are equipped with a type of steering gear known as the *Worm and Sector;* but others, especially among the lighter and cheaper cars, have steering gears equipped with pinions or spur gears. As a rule the gears themselves give little trouble and require little care, with the exception of keeping them well greased and taking up the adjustment for wear from time to time. Connecting the gears proper with the front wheels are

two rods or tubes; one connecting the arm at the lower end of the steering column at one wheel, and known as the *Reach Rod,* the other connecting the two wheels and known as the *Cross Rod.* At the ends of each of these rods are ball-and-socket bearings, and these are the parts which usually require most attention. A vast amount of wear and strain comes upon these bearings, for they not only take all the strain of steering, but also resist the tendency of the wheels to turn or swing on inequalities of the road, on curves, et cetera. Moreover, they are below the springs and receive the full benefit of all jars, knocks, and vibrations, and are usually covered with dust, water, or mud. These joints should always be kept well adjusted; they should be packed with grease frequently, and they should be protected from mud and dust by leather covers or boots. Another portion of the steering gear which should be kept in mind is the bearings at the ends of the front axle, and which allow the wheels to swing when turning the car. They are usually plain bearings provided with take-up adjustments and grease cups, and they should always be kept well lubricated and carefully adjusted. If through wear these bearings become loose, the front wheels will work back and forth and will get out of line, which is most destructive to tires and makes the car steer badly, as well as bringing undue strains on the steering gear.

Practically all modern cars are provided with electric lights and self-starters. The lighting and starting systems are usually very mysterious affairs to most people, and many of them are in reality very complicated and have a multiplicity of wires which are confusing; but in principle they are very simple. A self-starting system

consists of a dynamo or generator, a motor, and a storage battery. The generator produces an electrical current when the motor is running, and this is led into the storage battery, which possesses the property of accumulating electricity and storing it until proper connections are made, when the stored current is given off. The motor is much like a generator or dynamo reversed; for, whereas the revolutions of the dynamo produce electricity, a current of electricity passed through the motor causes the shaft of latter to revolve and produce power. The motor is connected with the flywheel of the engine by means of gears or pinions, which may be thrown into mesh at will. When the self-starter pedal is pressed, the electric motor is thrown into mesh with the flywheel and a current of electricity is passed through it, thus causing the motor shaft to revolve and turn the flywheel of the engine exactly as if it were cranked by hand.

As the electric motor consumes a great deal of electricity, the battery would soon be exhausted if it was not constantly refilled or recharged with electricity, and it is to keep the battery fully charged that the generator is provided. It is a very easy matter to see that the battery is being constantly charged, for a clocklike dial known as an *Ampmeter* is placed on the dash, and this indicates whether the batteries are being charged or discharged. If at any time, when the motor is running, the dial fails to register *charging,* or if with the lights turned on or the starter in operation it fails to register a *discharge,* you should remedy the trouble at once; or, better still, go to the nearest service station of the makers of the car or of the starting and lighting system.

As the lighting system is operated by the current from

the storage batteries, and consists merely of wires led to the lights and to a switch, no explanation of its principle or details is necessary. Many cars also use the current from the storage battery for ignition, and in order to obtain satisfactory operation of the engine the battery must be kept fully charged at all times.

CARING FOR A MOTOR CAR

As I have already mentioned, every owner or user of a car should be familiar with its mechanical details before attempting to learn to drive. I do not mean by this that you should know everything about the thousand and one parts, or that you should attempt to make a serious study of mechanics; but in order to care for a car properly you must know something of its operation, its parts, and their purposes, because no car can be depended upon unless it is properly cared for.

Even if you employ a chauffeur, or keep your car in a public garage where there are competent mechanics, it is very unwise to depend wholly upon others to keep the machine in the pink of condition. Neither the chauffeur nor the garage man takes the personal interest in the car that you do yourself, and it's not their pocketbooks that suffer if anything goes wrong and expensive repairs are necessary—rather, it is to their advantage. It is an easy and simple matter to inspect your car and see that everything is properly taken care of, and a few minutes spent this way will result in a vast saving of time and money in the long run.

Few men would dream of starting out with a car with its paint covered with grease and mud, or with its metalwork corroded and dirty, yet not one man in a score can show a decently clean and well-kept motor under his car's bonnet, and yet the motor is the most important and essential part of the car, and all the shiny paint and nickel in the world will not make a car run well if the motor is neglected.

If you wish to get the utmost value out of your car, if you take pride in its performance, if you are looking for economy in upkeep, or if you wish to avoid vexatious breakdowns and accidents, look after the inside of your car as carefully as the outside. Examine the motor before and after every trip or long run; see that it is kept clean and runs quietly and smoothly and that it throttles down until it is barely turning over. If there is a rattle, squeak, or grind, or the least trace of a pound or clank, locate the trouble and remedy it at once. Don't wait until some part is worn out, but make adjustments, replacements, and minor repairs as soon as the parts show the least lost motion or unusual noise. Don't forget that every motor must have oil and fuel and that all water-cooled motors require water. Use only the best oil and don't feed too much or too little; there is a definite quantity required, and an excess is bad for the motor. Moreover, it is a useless waste of money. Fill up your radiator before you start out, even for a short trip, and whenever you stop see that it's full. If your radiator steams or boils, something is radically wrong and the trouble must be remedied at once. If there is a leak in your radiator, or anywhere in the water system, fix it is soon as possible; it is a nuisance to have continually to fill the radiator, and, besides, the efficiency of the cooling system suffers. See that all the grease cups are kept full of grease, and give them a turn or two every few days. Watch the springs and see that they are not loose on their seats, that a leaf is not broken or cracked, and keep the leaves oiled. Examine the steering gear; keep it clean and well lubricated, and if any part is loose or rattles, tighten up the necessary adjustments at once. Be sure your fan belt is not slipping; see that the packing

on the water pump is tight; drain out the carburetor once in a while, especially in damp or rainy weather; draw off the oil from the crank case and replace with fresh oil occasionally; keep the gear case, universal, and differential packed with grease of the grade recommended by the maker of the car; be sure the brakes are properly adjusted and the joints in their rods are oiled and don't stick; and now and then jack up the front wheels and test them for play or looseness in the ball bearings of the hubs or the plain bearings at the axle ends. If you wish a quiet car, watch out for loose mudguard fastenings, loose lamp glasses and connections, a loose bonnet, a shaky wind shield, and rattling doors. If everything is kept tight, if all moving parts are kept well oiled, if the motor, axles, steering gear, hubs, brakes, and all other parts are kept clean, your car will give you steady, reliable, economical, and long service. And don't forget the ignition, the starting, and the lighting systems. Examine all the wires and their connections at frequent intervals; run the motor in the dark and watch for flashes of light; see that none of the wires touch metal or are exposed to water, grease, or mud; clean the spark plugs and give the magneto, generator, and other moving parts of the electrical system a drop of oil now and then, and you'll seldom be held up through ignition troubles. Don't overlook the battery. See that its terminals and connections are clean, bright, and free from corrosion; keep the battery free from water, mud, and dirt; keep the cells filled with *distilled* water to the proper level, and your battery troubles will be a thing of the past.

Remember that water will freeze, and as soon as cold weather sets in add some antifreezing mixture—dena-

tured alcohol is the best—to the water in the radiator. Don't wait till it does freeze; put it in ahead of time.

Finally there are the tires. Tires, as a rule, figure more largely in upkeep than any other item on a car, and ninety per cent of tire expense is due to lack of care and attention. Perhaps more tires are prematurely destroyed by lack of proper inflation than by any other one cause. It is only a few moments' work to inflate your tires to the proper pressure, especially with a motor-driven or spark-plug pump; and even with a hand pump it does not take half as long as to change a tire and pump it up. But somehow or other the average motorist seems to have an inborn dread of doing anything to his tires until they fail, and one constantly sees cars being driven with their tires half flat. Every tire is designed to support a definite load when it is filled with a certain pressure of air, and if the pressure is less than was intended by the makers the tire is suffering at every foot it travels and its life is going to be shortened. No man with any brains would attempt to carry a load greater than his strength would permit, and yet that's just what he expects his tires to do if he doesn't keep them inflated to the proper pressure. But there are many other things which decrease the life of a tire and increase upkeep expenses. Letting a tire stand in oil or grease will soon ruin it; a rusty or dirty rim will play havoc with tubes and casings; the use of chains when not necessary is injurious; swinging around curves without throwing out the clutch or slowing down spells tire expense; slamming on brakes so that the wheels slide will wear a tire more in ten seconds than would normal use in a hundred miles; and excessively fast driving is a terrific strain on tires. Keep tires clean; keep them inflated to the proper pressure;

keep the rims clean and free from rust; slow down or throw out the clutch when rounding corners, traveling on car tracks, macadam, or rough roads; use your brakes gently and gradually and keep your spare tubes and shoes clean and protected from sun and weather, and you will cut your tire bills in half. When the car is laid up for the winter, jack it up and keep its weight off the tires. Of course blow-outs and punctures will occur. They are unavoidable; but much can be accomplished if you use tires of standard makes, new stock, and, if possible, oversize. Last, and by no means least, never take anything for granted. You may think your fuel tank is full; you may have every reason to believe that the motor is supplied with oil, that grease is in the gear case and differential; you may be confident that your tires are properly inflated, and you may feel sure the radiator contains water; but it is far easier to look at your fuel tank, to fill your radiator, to examine your oil gauge, and to test your tire pressure than it is to tramp miles to get gasoline or to have your motor ruined or your tires blown out.

In caring for a motor car, in driving it, in everything connected with it *be sure you're right before going ahead.* Take nothing for granted, assume nothing, make care a habit and "Safety First" a monomania, and always bear in mind the old adage: "If you want a thing well done, do it yourself."

LEARNING TO DRIVE

The first step in learning to drive a car is to learn the uses of the various controls and to become thoroughly familiar with them. The controls of a car consist of spark and throttle, the clutch pedal, the gear-shift lever, and the brake levers or pedals. The throttle and spark levers are usually placed on the top of the steering column, while an auxiliary throttle control known as an *Accelerator* is usually placed on the floor of the car and is operated by the driver's foot. The throttle lever operates a valve at the carburetor which regulates the size of the charge of gas entering the cylinders. Closing the throttle slows down the motor, and opening it increases the speed and power of the motor. Although some drivers use the hand throttle lever for controlling the motor, it is a much better plan to use the foot control or accelerator and keep the hand lever at its closed position, so that the motor runs very slowly when idling. The speed of the motor is also partly controlled by the spark lever. This operates by moving the distributor, or breaker, and thus causing the spark to occur in the cylinders either earlier or later in relation to the position of the piston on the firing stroke. If the spark is retarded, the explosion occurs when the piston is just at the upward limit of its stroke or slightly after; whereas, if advanced, the spark takes place just before the piston reaches its upward limit.

To get the highest efficiency from the motor, the spark should be advanced as far as possible without causing the motor to knock or pound, and it is seldom necessary to change it unless climbing a stiff hill or pulling through

heavy mud, sand, snow, or running with the motor throttled down. As long as the motor runs well and does not pound, the spark should be kept advanced; but at the first sound of laboring or pounding it should be retarded until the motor runs smoothly.

The gear-shift lever is usually placed in the center of the floor in modern cars, but it is often at one side—usually at the right—of the driver's seat. Its purpose is to move the gears from one speed to another, as already explained; and when the car is not traveling it should always remain in the central or neutral position. The clutch pedal is a foot pedal, usually the pedal on the left, and its purpose is to disengage or throw out the clutch when the gears are shifted or, in case of emergency, when stopping suddenly, et cetera. The brakes are usually operated by a foot pedal for the service brake and a hand lever for the emergency brake; but in some cars the clutch pedal also acts as the service-brake pedal, while the second pedal operates the emergency brake, and there is no hand lever.

When the car is not in use, the emergency brake should always be left on. In addition to these controls, there is a switch, usually on the dash, for turning on or off the ignition current; switches for turning on or off the lights; a pedal or foot button for operating the self-starter, and a lever or handle known as the "choke." This is for the purpose of cutting off the air intake to the carburetor and drawing in a rich charge of gas; ordinarily it is used only when starting the motor.

It is a very wise plan to learn to operate the various controls, to shift gears, and to apply brakes with the car stationary; and when you have become accustomed to them and can shift gears quickly, quietly, and easily, can

control the speed of the motor, and can apply the brakes without stopping to think what you are doing or fumbling for controls, you may take the car out for a road trial.

To learn to operate a car when stationary is much easier than to learn on the road, for there is no danger of an accident; you do not have your attention distracted by learning to steer or avoiding other vehicles and bad spots, and there is no feeling or nervousness.

Moreover, if you learn to handle the controls with the car stationary, all you have to learn on the road is to steer, and you can devote your entire attention to that.

The first thing to do is to jack up the rear axle until the rear wheels are clear of the floor or ground. Then put good solid blocking under the axle, place blocks or heavy cleats in front of and behind the front wheels, and see that the car cannot shake off the blocking under the axle and that the front wheels are locked by the blocks in front of and behind them. Then be sure the gear-shift lever is in neutral, that the emergency brake is set hard and locked, that the radiator is filled, that the motor base is properly provided with oil, and that there is fuel in the tank. Advance the spark lever slightly, open the throttle about one-third, and you are ready to start the motor. If, as is probably the case, the car is provided with a self-starter, it is only necessary to turn on the ignition switch, press down on the starter button, and if the motor does not start after a few revolutions, close the choke. As soon as the motor starts, take your foot off the starter button, open the choke, and then gradually close the throttle and advance the spark until the motor is idling smoothly and quietly. If it misses or seems about to stop, open the throttle a little more; and if it sputters or backfires, partly close the choke until the motor is warmed up. If

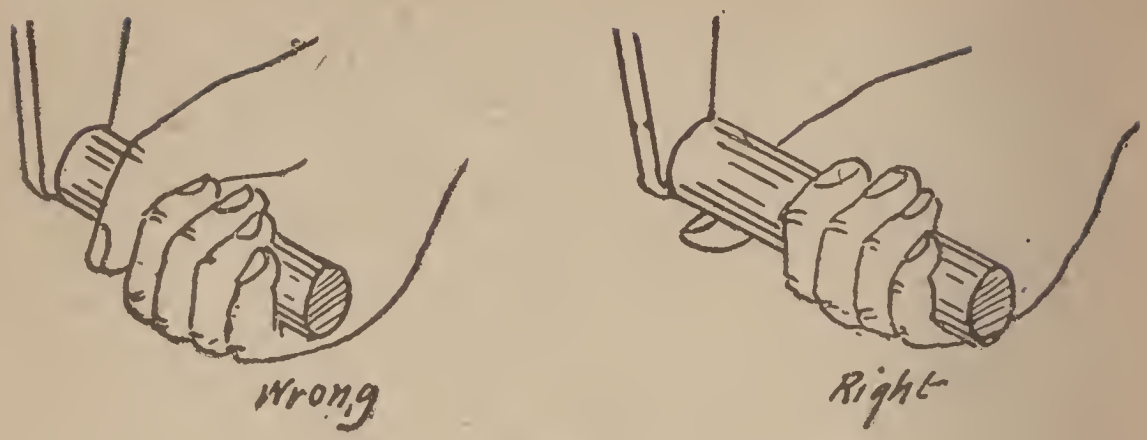


Fig. 17

FIG. 17—How to hold a crank.

the car does not have a self-starter and must be cranked by hand, partly open the throttle, retard the spark, and, inserting the crank, turn the motor over quickly, and, as soon as started, throttle down as directed. Before cranking a motor be sure that you know how to do it. It may seem like a very simple matter, but many a man's arm or wrist has been broken by lack of care or knowledge in cranking a motor, and not one man in a dozen cranks a car properly and with due regard to his own safety.

In the first place, always be particularly careful to see that the gears are not in mesh; if they are, and the car starts, you may be knocked down, run over, and killed. In the second place, retard the spark fully; if the spark is advanced, the engine may "kick back" and break your arm or wrist. *Don't* start to crank the motor with the handle of the crank uppermost, so that you have to press down on it; have the handle down and start to crank by *pulling up*. Use your *left* hand, if possible, then if anything happens you will not lose the use of your right hand, at any rate. *Don't* grasp the crank handle with your fingers on one side and your thumb on the other; keep your thumb on the same side as your fingers, so that if the crank kicks back it won't tear your hand. *(Fig. 17.)*

If the motor doesn't start after one or two turns, prime it; or, in other words, inject some gasoline into the cylinders through the cylinder relief cocks, or, if provided with a choke, use this instead.

It is seldom necessary to spin a motor, or, in other words, to whirl it around and around; if the crank is pulled sharply up several times, the motor should start if it is properly adjusted and everything is all right. If you cannot start it in this way, throw off the switch, spin the motor, throw on the switch, and move the spark lever back and forth; this will often start a very obstinate motor, and it is far safer than spinning it with the switch on. A self-starter avoids all this hard work and the danger of cranking, and if your car is not equipped with such a device, by all means have one put on; it is a good investment. Nevertheless, you should know how to crank a car, for the best of self-starters fails at times, and then cranking may become necessary.

Having started the motor, and having throttled it down until it is running smoothly and slowly, accustom yourself to the use of the clutch, brake, and accelerator pedals. Practice throwing out the clutch and letting it in slowly and smoothly; practice touching the accelerator and speeding up the engine, not with a sudden rush and roar, but so that it picks up speed quickly and smoothly. Then learn to shift gears. Release the brakes, and, with the engine running slowly, depress the clutch pedal, grasp the gear lever, and move it into the first-speed position, probably to the left and back. Then let the clutch in gently, and at the instant it takes hold speed up the motor slightly with the accelerator. Then try using the foot brake. Take your foot off the accelerator, throw out the clutch, and apply the brakes. *Don't* shove down the

brake pedal suddenly, but push it firmly and steadily, bringing the wheels to a gradual stop. Next try using the emergency brake. Apply the service brake as before and also apply the emergency, exerting your pull evenly and firmly. To slam the brakes on suddenly is a strain on the car and is ruinous to tires. Moreover, it is never necessary, as a car can be brought to a full stop just as quickly by a firm, smooth application. Keep the clutch depressed while the brakes are on, release brakes, let in clutch, and speed up with accelerator. Repeat this until each motion becomes almost automatic, as this is something you will be called upon to do many times when actually driving. Now practice the operations necessary when stopping at the curb or elsewhere. Throw out the clutch, move gear-shift lever from first speed into neutral, and apply brakes and let in clutch at the same time. If you hear the least grinding or grating sound in the gears, you may be sure that you have not thrown the clutch entirely out or that you have let it in too soon, or that you have thrown the shift lever too far and partly into another speed. Keep at it until you can do it all swiftly, easily, and silently, and then try shifting gears from first to second speed. To do this, throw out clutch, move lever to second-speed position—if left and back was first, right and forward will be second——let clutch in smoothly and speed up motor exactly as when getting into first speed. Then try shifting from second back into neutral by throwing out clutch, moving lever into neutral position, and applying brakes. Then practice shifting into first, from first into second, and from second into third or high speed. Remember to *throw out the clutch whenever the gear-shift lever is to be moved from one position to another, and don't let it in until the lever has*

been moved to the limit of its throw. Don't let the motor race; keep it throttled down and barely turning over when shifting gears, as the car is not on the road the engine is not doing any work, and the wheels will spin and make gear shifting difficult if the motor is speeded up. If the wheels should spin and there is difficulty in shifting gears, apply the emergency brake slightly and leave it locked in that position. This will have the same effect as if the car were traveling on the road.

When you are thoroughly familiar with the controls and their operation, when you can shift gears easily, noiselessly, and smoothly and feel perfectly at home with the pedals, levers, et cetera, you can safely try a road lesson.

Let me suggest here that the quickest and best way to learn to drive a car is to have some competent driver in the car with you—one who can teach you all the little knacks and tricks of driving far more quickly than you can acquire them yourself. There is only one objection to having another teach you, and that is that you are very likely to learn his faults and his mistakes along with other things, and it's much harder to unlearn than to learn.

FIRST LESSONS ON THE ROAD

If your car is in a garage or other building with a narrow doorway, or if you are obliged to pass through a gate to reach the road, it is a wise plan to push or drag your car to the road. A slight mistake, the least nervousness or lack of skill, may result in knocking down a fence or a door frame, and, as pleasure cars were never built to serve as "tanks," a bent mudguard, a smashed radiator, or a broken wheel may result.

Choose a smooth, straight road for your first attempts, and if you cannot find an unfrequented place choose an hour when traffic is at its minimum. Don't attempt to learn to drive on a narrow, crooked, or hilly road; on a road with deep ruts, holes, and bumps; or on a road bordered by deep ditches or with many crossroads; and, above all, don't start to learn on a road where there is a trolley track or a trolley or railway crossing. Also be sure to select a dry day and a time when the roads are neither wet, muddy, icy, nor slippery.

Having looked after all these various details, start your motor, grasp the steering wheel, throw out the clutch, shift to first speed, and let the clutch in very slowly and gently, at the same time speeding up the engine slightly by means of the accelerator. As the clutch takes hold the car will move slowly forward, for even with the motor running quite fast a car on low or first gear will barely crawl along. Let the car travel on first gear for a few hundred feet, or until you get the "hang" of the steering gear, and then shift to second speed in exactly the same manner as you did with the car jacked up. The

pace of the car will now be considerably increased, and you may begin to have some difficulty in steering. The greatest mistake that beginners make is to move the steering wheel too much. Only a very slight motion is required to swing the car to right or left, and by holding the wheel firmly but not immovably and moving it slightly you will soon learn to keep the car traveling in a fairly straight course. Don't let it run far to one side and then bring it back with a quick pull; correct any tendency to swerve before or as soon as it is noticeable, for the whole knack of skillful, perfect steering consists of overcoming a variation in steering before the deviation occurs. In other words, one must instinctively swing the car back and forth on its course by "feel," and at the same time must do it so easily, quickly, and with such a slight motion that the car maintains a straight course and does not zigzag like a drunken man all over the road. If, when learning, you see another vehicle approaching, or hear another overtaking you from the rear, the wise plan is to stop your car on the right-hand side of the road and wait for the others to pass, for it is a dangerous matter for a beginner to attempt to pass another vehicle. In the first place, the other chap does not know you are green, and he may assume you are a skilled driver and tear past with only a few inches to spare. In the second place, there is a psychological effect in a passing or approaching car which tends to make a beginner turn *toward* the other vehicle, and which is often so strong it cannot be overcome for some time.

As soon as you can steer fairly well on second speed, shift into third or high, but drive slowly and cautiously, for accidents happen in the twinkle of an eyelid when a car is moving rapidly. Of course you should also prac-

tice stopping and starting by throwing out the clutch, shoving on the brakes, and moving the gear-shift lever into neutral; and you should also practice slowing down and stopping without disengaging gears by using the clutch and brakes alone. But don't come to a dead stop in this way and then attempt to start again if your gears are in third speed. Whenever you are at a standstill, start on first, then when the car is moving shift to second and then into third. Many cars can be started on second and many on third on a smooth, level road by a competent and practiced driver; but the beginner should never attempt this feat and should always "go through" the gears from first up whenever the car is started from a full stop.

You must also learn to reverse your car and turn around, for these are very important matters. Try running your car backward and keeping it in a straight line, and become accustomed to handling the steering wheel while reversing. Then select a wide, clear space and try turning.

First run your car as far to the right-hand side of the road as possible, come to a stop, and shift into low or first gear. Then swing your car sharply to the left, turning the wheel as far over as possible, and if the road is wide enough you will have no difficulty in turning completely around; but the chances are that there will not be space to turn and you will be compelled to go through certain evolutions to get the car around. When you are as near the edge of the road as you can safely go, bring the car to a full stop, shift to reverse gear, turn the front wheels hard over in the opposite direction, and slowly run the car backward. Then stop, shift to first, turn the steering wheel to swing the car to the left, and go ahead. All this

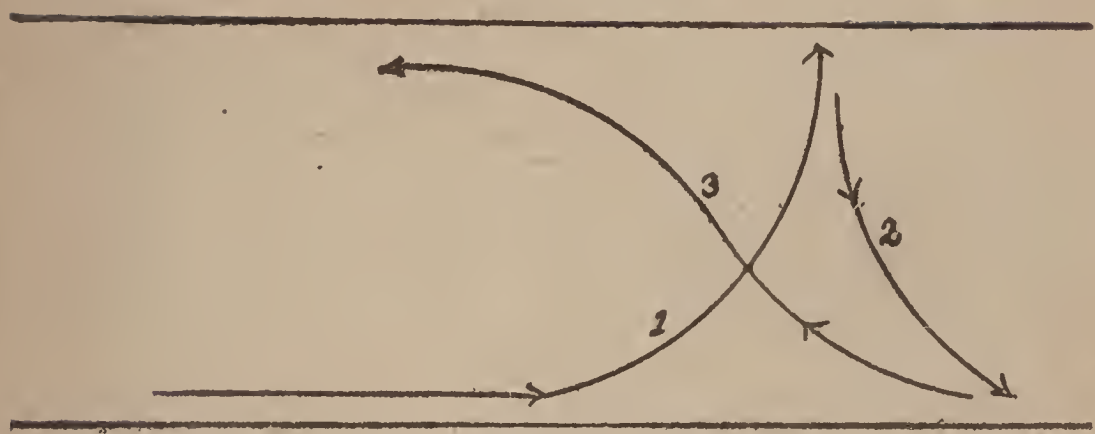


Fig. 18

FIG. 18—Turning around.

is very simple and is shown in the diagram, *Fig. 18.* You will soon be able to accomplish it quickly, neatly, and without a hitch. Moreover, it is mighty good practice, for it teaches you to judge of the possibility of turning, of how far to swing the car to accomplish a desired result, and to gauge the turns your car makes under varying conditions.

After learning these matters, you can give your attention to passing and being passed by other vehicles, to turning corners, to climbing hills, to coasting, et cetera.

The main thing in passing or being passed by another vehicle is to slow down, give the other fellow plenty of room, and keep your eyes on your car and the road, not on the other car.

There is a right and a wrong way of passing other vehicles, and it is far easier to learn the right way first than to unlearn the wrong way later. If you are approaching another vehicle, either from the rear or head on, don't continue in a straight line until the last minute and then suddenly swing sharply out. If anything happens, if your car skids, if the steering gear jams or fails, or your motor skips, you may crash into the other vehicle,

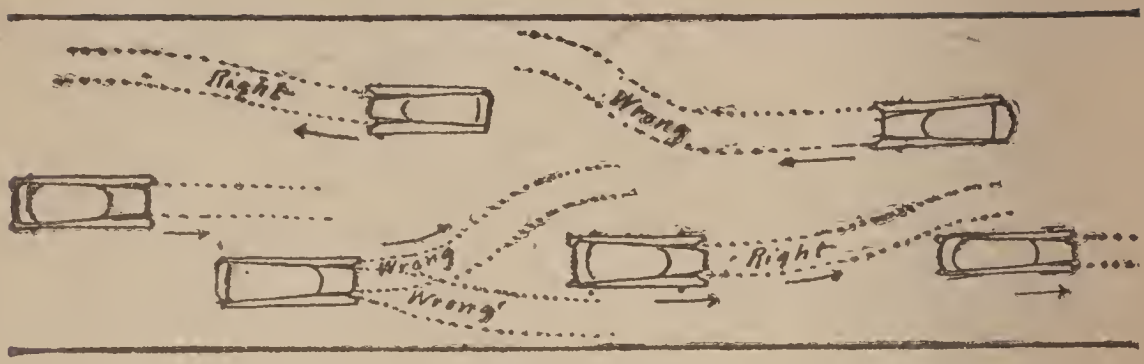


Fig. 19

FIG. 19—Passing other vehicles.

and, besides, it is a strain on the steering gear and car. Swing gradually to the left or right, as the case may be, and turn back into your straight course in the same way. Then the other fellow knows of your intention as soon as you commence to turn, there is no danger of some vehicle behind you crashing into your car, and there is less danger of accident from any cause. Moreover, if you wait until you are close to another car and then turn, you may find yourself in imminent danger of a collision with some car which has been hidden from your view; whereas, by swinging around gradually, you have an unobstructed view ahead long before there is danger of a collision. This may perhaps be more clearly understood by the diagram, *Fig. 19*.

Finally, don't try to pass other cars with only a few inches to spare; it does not show good driving, as many seem to think, but instead it is proof of carelessness, stupidity, and lack of common sense. If a tire goes flat, if a rut, stone, or other object is in your path, if the car skids or either driver swerves in the least, an accident may follow. Allow at least a foot between your car and the other, and *don't attempt to pass another moving car unless there is that much room to spare.*

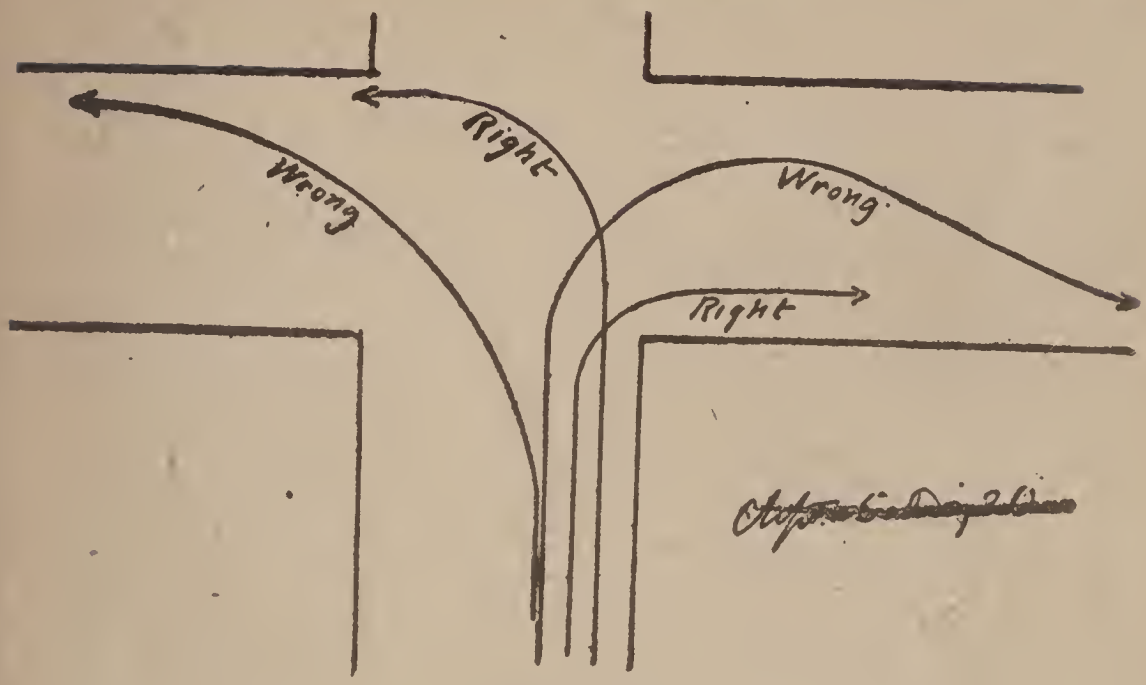


Fig. 20

FIG. 20—Turning corners.

In turning corners, slow down; don't try to swing around too sharply, throw out your clutch and let the car coast or glide around the curve. Remember *always* to sound your horn when approaching another vehicle or when about to turn a corner, as well as when there are pedestrians or intersecting roads ahead. When turning a corner, don't swing across the whole width of the street. In turning to the right, hug the right-hand curb; and if turning to the left, keep to the right across the intersecting street, and then, swinging to the left, continue along the right-hand side, as shown in *Fig. 20.*

Then practice stopping at a given spot or in a given distance. Place some object, such as a white rag, on the road or beside it, run toward it at fairly good speed, and see how close to the object you can stop the car. A little practice of this sort will soon enable you to judge very accurately the distance required to come to a standstill

at various speeds; but *don't* slam on brakes and lock your wheels so they slide. Use the service brake first, and then the emergency, and use them both intelligently and with even, steady pressure.

The next most important thing to learn is to *shift down* with the gears. In some cars this is far easier than in others, owing to the details of gear construction; but the principle is the same in all cases. In shifting up from low to high there is little difficulty, for the engine under a load is moving faster than the propeller shaft and driving gears, and as the clutch is thrown out and the motor slows down the gears mesh easily; but when shifting down from a higher gear to a lower, the speed of the driving gears is increased beyond the speed of the motor and injury to gears, motor, and other parts may easily result if the operation is not carried out properly. The method of accomplishing this is known as *double declutching,* and every driver should know how to do it easily, smoothly, and quickly, as it is often very necessary. For example, if you are climbing a hill on high and find the grade too stiff, it will be necessary to shift to a lower gear to make the hill; but this will be impossible unless you understand double declutching perfectly.

Again, you may often be traveling fairly rapidly, and, upon coming to a bad spot—a sudden hill, congested traffic in a city, or a corner—it may be necessary to get into a lower speed. Of course, in such a case you can bring your car to a full stop, start in low, and go through the gears to the one you desire, but it is much easier and better to be able to shift down.

In a nutshell, the whole secret lies in bringing the speed of the motor with the various gears into uniform ratio. Hence, as the motor must be slowed down in

changing gears up, just the reverse is the case in shifting down, and the motor must be speeded up when shifting.

This may be accomplished by throwing out the clutch, shifting the lever to neutral, letting in the clutch, and accelerating the motor, and then throwing out the clutch and shifting the lever to the lower speed, when the clutch may be let in and the motor speeded up. As a matter of fact, the operation is much simpler than it sounds in a description, and once you master the proper sequence of movements the change from a high to a lower gear can be made almost as quickly and easily as from low to a higher gear. Don't attempt to shift from third to first, or even from second to first, until you are proficient in the art. Try from third to second with the car moving as slowly as possible on third, and be sure to let the clutch slip in very softly and so that it takes hold gradually. Then, when this can be accomplished, try it with the car traveling at a more rapid pace, and finally practice getting from second into first; but *never* attempt going from third to first, and *never, never shift into reverse from a forward speed, or into a forward speed from reverse, until your car has come to a full stop!*

In driving on hills, the most important matter is to know just what gear to use, and this is something that depends entirely upon the hill, your car, and the load you are carrying. Most modern cars will take any ordinary hill on high; but if the road is rutty, rough, wet, slippery, or crooked, always slow down or take it on second or first. Remember that a car is always under better control on low gears than on high, and that it always is easier to shift from a low gear to a high than vice versa. Moreover, even if your car will take the hill on high, it may be putting an undue strain on the motor and trans-

mission to attempt it, and a car climbing easily up a hill on second will often move faster than if laboriously struggling up on high. But the ability to judge which speed to use in hill climbing will only come with experience, and after driving a short time you will be able to tell at a glance whether your car can sail over a hill on high or whether it is necessary to drop back into second. If your car is climbing on high speed, and the motor commences to pound or knock, retard the spark; and if it still pounds and labors, shift to second, or even to first speed.

The greatest danger in climbing a steep hill lies in your car stalling and running backward down the slope, and the chances of becoming stalled are far greater on high than on low gear. If your motor stops on a hill, shove on both sets of brakes to the limit, throw your gears into *reverse,* and shut off ignition and open throttle. This may seem a strange thing to do if your car is moving backward, but if you stop to think of it you will understand the reason. The reverse gears are usually the lowest gears of all, and, just as the motor's power is increased by driving through these gears, so the power of the wheels is decreased when they are driving the motor. In other words, the motor when driving through low or reverse gears revolves much more rapidly than the wheels; and so, when the motor is shut off and the car is moving, the motor is forced to revolve at increased speed, and with the ignition shut off and the throttle open each of the cylinders will act as a pump and the resistance exerted by the pressure in the cylinders will serve as a brake. Even if it does not stop the car entirely, it will decrease its speed to such an extent that it may easily be guided safely to the foot of the hill or brought

to a standstill by running it gently and gradually into a bank beside the road.

If you have a companion with you, let him jump out as soon as the car slows down sufficiently to permit it, and, by placing stones or a piece of wood back of the wheels, the car can be brought to a standstill. In fact, in many cases a car which cannot be completely stopped by the brakes may be brought to a full stop by a man pushing against it, for oftentimes only a very slight additional effort is required to check the movement. *Never* attempt to start a car forward on a hill when it is moving backward. Bring it to a full stop before starting on a forward gear. A car cannot travel both ways at once, and if you start the motor and throw in a forward gear when the car is moving backward the chances are you'll strip your gears or wreck the motor or transmission.

In case you wish to stop when going uphill, bring your car to the side of the road, turn your forward wheels toward the side as far as they will go, and let your rear wheel jam against the curb, bank, or wall that borders the road; then, if your brakes should slip, there is no danger of the car running wild down the hill. *(Fig. 21.)*

In some ways, driving down a hill requires far more skill and care and is far more dangerous than driving uphill. It may seem a very easy and simple matter to throw off the clutch, shift your lever to neutral, and gayly coast downhill, but this is exactly what you should *not* do.

If the hill is not very long or steep and it is a clear, straight road with no hidden crossroads, there is little danger in coasting with clutch thrown out and gears in high; but be sure and keep one foot on the service brake, be ready to seize the emergency at an instant's notice, and keep your motor going. But as a rule the only safe

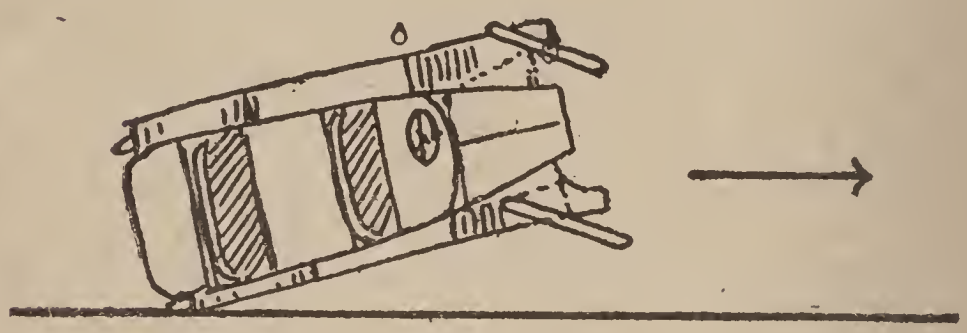


Fig. 21

FIG. 21—Stopping on a hill.

method is to shift into second or even first gear at the top of the hill, open the throttle, shut off ignition, and throw out the clutch. Then, if your car's speed becomes too great and you cannot control it with the brakes, let in the clutch and let the motor serve as an additional check. The safest and best method of all, especially on a bad hill and with a heavy car, is to keep the motor running with the gears in first or second speed and keep the clutch *in*. Then, by a judicious use of the brakes, the car may be kept under perfect control. But *don't* throw out the clutch and let it in again under these conditions, for the strain on gears and motor is tremendous and something will be injured or broken. Whichever method you use, it is a wise plan to depend mainly on the motor as a check and use the brakes merely as a supplementary control; for if the brakes are kept on they will heat, wear, and burn, whereas using the motor will serve to cool it off and will save the brakes.

If the motor has been shut off, it may be started again when the bottom of the hill is reached and the car slows down by switching on the ignition; but as soon as it

starts, throw out the clutch, and, when the car is almost at a standstill, let the clutch in gently as if you were just starting. Perhaps the greatest danger in descending hills lies in crossroads. Very often these roads are concealed by bushes, fences, et cetera, and if you are traveling rapidly a collision may result, for it is a difficult matter to stop a car suddenly on a hill. Sound your horn, keep the car under control, and don't coast fast when there are any crossroads or houses with driveways beside the road. Another grave danger on hills is meeting another vehicle. The car or team coming uphill is traveling slowly and cannot swing to one side quickly, and your car is moving rapidly and unless you remember and make allowance for this and give way for the other fellow an accident may result. But don't attempt to turn out to one side with your car racing downhill, for if you do you'll probably find yourself lying bruised and injured in the ditch and your car a wreck. Always bear in mind that a car moving rapidly has a tremendous amount of momentum and that its tendency is to continue in a straight line. If the front wheels are turned, this tendency will cause the car to slide sideways, to tip, or to fly off the road, and the crown or curve of the road surface aids in doing this. If you have ever noticed a railway track or a race course, you may have observed that on the curves the outer side or rail is higher than the inner side or rail. This is to overcome the natural tendency of a moving body to tip toward or fly off the outer side of a curve, or, in technical terms, to overcome the centrifugal force. On a highway the sides are lower than the center, and hence in making a turn to one side the tendency to fly off, or the centrifugal force, is made even greater than normal. So be *very, very* cautious in taking

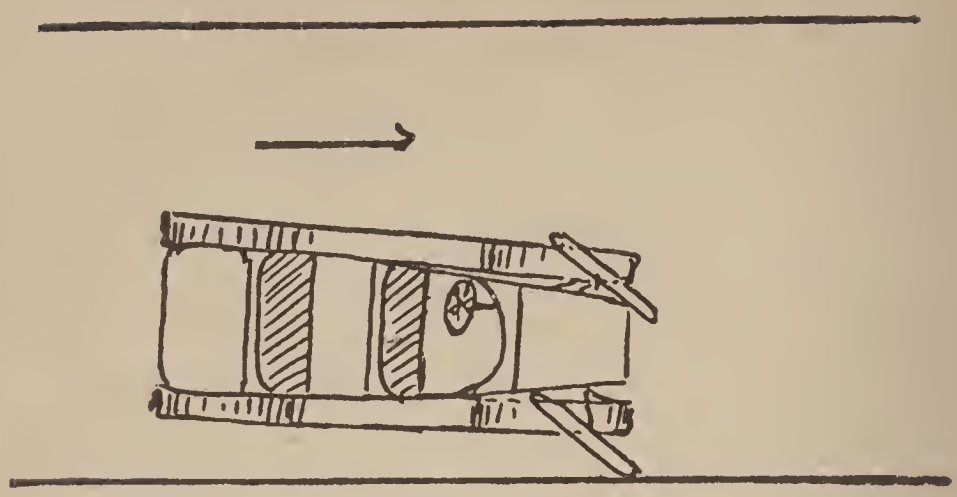


Fig. 22

FIG. 22—Stopping on a down grade.

turns or in swinging out to pass vehicles, and *never* attempt it when traveling rapidly.

If you should wish to stop the car or to leave it on a down grade, run the car close to the curb or bank and turn the front wheels until they bear against the curb or bank. Then if the brakes slip, the car will jam against the obstruction and will not run away and be wrecked. *(Fig. 22.)*

Finally there is night driving. A man may be an expert and competent driver by daylight, and yet he may find night driving very difficult. It is a good plan to practice night driving, for experience is the only method of becoming a competent night driver. In the dark one's vision is confined to objects near at hand, and it is very difficult to judge distances or speed, and even with the best and most powerful lights objects have a most disconcerting way of seeming to leap out of nothingness into your path, while in turning corners or curves everything beyond the turn is invisible until your car swings enough to throw the lights ahead. Far greater care and caution must be used when driving at night than in the

day; and even on open, lonely country roads you must be ever on the alert, ready to check your car at an instant's notice, and with your entire attention concentrated on the road ahead. At any moment a stray animal or a pedestrian may step from the wayside into your path, while crossroads and driveways, plainly visible by daylight, cannot be distinguished at night until you are close upon them, and your lights will not reveal a vehicle, a pedestrian, or an animal traveling on the crossroad. In addition, there is the ever-present danger of overtaking or meeting some cart or wagon, or a herd of cattle or sheep; while, if there are trees which cast heavy shadows, it is almost impossible to distinguish between the irregular dark patches and obstructions in the road. Still another great danger in night driving is the glare of powerful lights on approaching motor cars and trolleys. Of course any decent driver will dim his lights, if not equipped with nonblinding glasses, when approaching another vehicle; but many drivers are reckless—they care nothing for the safety of themselves or others, and they take a fiendish pleasure in blinding any driver they meet. If you see a dazzling light approaching, the only safe course is to turn out as far as possible, slow down, and proceed cautiously or even stop your car and wait for the other car to pass. It is better to be safe than sorry, and it is no reflection on your skill to let the road hog have his way. Much of the dazzling effect may be overcome by using green or yellow goggles, or by using a colored transparent disk on the wind shield; while on a level road one hand held before your eyes, or even a hat brim turned down, will prove a great help. Always remember that a red light means danger, and whenever you see it slow down or stop until you find out what lies ahead.

And now a word in regard to driving over bad spots. Try to avoid such places as much as possible, and train your eyes and hands to work together to select the best parts of the road instinctively. A patch of loose macadam, a stretch of soft mud or sand or water may cause a car to skid, swerve, or overturn if you are moving rapidly, especially if in trying to check your speed to take the bad spot you apply the brakes, or if in turning aside to avoid it one wheel remains on a firm, hard surface and the other is in the soft material. A careful and really expert driver will avoid such spots, and if they cannot be avoided the clutch should be thrown out, the service brake applied lightly, and the car allowed to coast or glide over the bad spot. This will relieve the motor and transmission of jars, strains, and jerks, and will largely reduce the danger of skidding. If there is a long stretch of bad road, slow down or stop and take the stretch on second or even first speed. Haste makes waste in driving a motor car, as in most things. Oftentimes, too, you may be called upon to drive your car in rainy, foggy, or snowy weather. If the roads are slippery, wet, muddy, or covered with snow or ice, be sure to use tire chains. Nonskid tire devices are all very well as far as they go, but you never can count on them, and in snow they are absolutely useless as the snow packs into the spaces between the projections and transforms them to slippery, smooth surfaces even worse than a plain-tread tire. In deep snow don't try to drive rapidly; it is impossible to do it with safety. But if you come to deep drifts, it may be necessary to rush them.

If you are going to drive in snow, carry along a shovel to dig through the worst spots, use chains on all four wheels, and be sure to have a good strong tow rope along.

If the car gets stuck, you can often pull it out by fastening one end of the rope around a post or tree and attaching the other end to a spoke of the rear wheel close to the hub. Then, by starting ahead on low gear, the wheel will act like a windlass and will pull the car forward on the rope. Oftentimes, too, a small rope wound around the tires will give far better traction than chains, and, moreover, it will not cut or injure the tires. Don't adjust the chains too tightly; they are supposed to slip on the tire so they will not come in the same spot all the time; and *don't* use chains on dry pavements or where they are not required; it will only result in undue tire wear.

Be extra cautious, too, when turning aside for another vehicle to pass, or when turning a corner on wet, icy, or snow-covered roads. Take the turn slowly, with clutch thrown out and brakes very lightly applied, and if there is snow use first gear and be careful not to get off the road and into a ditch which is concealed by the snow. Often there are deep ruts in snow, and sometimes the snow becomes frozen into a hard icy mass on either side. To turn out for another vehicle in such a place requires great care and caution, for it is a tremendous strain on steering gear, wheels, tires, car, and motor. Don't attempt it on high gear or when moving rapidly, but slow down or stop, use low gear, and try to select an irregular or low spot in the side of the ruts. Sometimes the only way is to get out and break or shovel away enough of the frozen mass to enable you to turn out. If possible, avoid such ruts, for the ice wears and cuts the sides of the tires like sharp rasps.

HANDLING CARS IN TRAFFIC

Driving a car on a country road is a very different matter from driving on the congested streets of a large city. Here emergencies are constantly occurring which call for quick, decisive, instinctive action, the ability to keep one's head under all conditions, and an almost intuitive sense by which the driver foresees and avoids an emergency before it occurs. At every minute the driver is confronted with problems which must be solved instantaneously. He must stop, start, turn, shift gears, signal to others, look after his own cars and all others besides; he must keep his mind on his driving and the traffic officers as well, and must have his car under absolutely perfect control. A moment's hesitation, the slightest mistake, the failure to notice or give a signal, attention diverted elsewhere for the fraction of a second may result in a serious accident. And to make matters worse there is a constant din and noise which is confusing. Finally, the driver cannot use his own judgment as to speed, path, or maneuvers, but must act in absolute unison with scores or hundreds of other vehicles, all under the direction of the traffic officers. If you have any tendency to get rattled or nervous, if you are not thoroughly familiar with the traffic regulations and with rules of the road, and if your eyes, brain, hands, ears, and feet will not work together in perfect unison, don't attempt to drive through crowded city streets. The test of a really good driver is in his ability to navigate the most congested streets in safety and ease, and you

should not feel satisfied with your ability as a driver until you feel as much at home and as self-confident in the steady stream of vehicles on a city street as on the open country roads.

Granted that you can keep your head, and that you have your car under perfect control; that you can concentrate your attention on the work in hand, even if you are carrying on a conversation with other occupants of the car, the most important essentials are to look out for the other fellow, make up your mind what to do, and *do* it. Don't vacillate; don't start to do one thing and then, after signaling your intention to others, suddenly change your mind. The drivers before and behind you, as well as beside you, are not mind readers, and if you signal you are about to turn a corner, and continue straight on, or vice versa, you can't blame them if they smash into you. And, speaking of the "other fellow," remember that he has just the same rights as yourself. Even if you are green or careless, and are willing to endanger your own car and its passengers, you have no right to imperil others. The drivers of the other cars don't know you're a beginner, at least until your inexperience becomes self-evident, and they assume that you wouldn't be driving in traffic if you didn't know how. They are usually skilled drivers, accustomed for years to traffic, and they can judge to the fraction of an inch just where to stop, and how much space to allow in passing another car. If you cannot do the same, if you swerve or stop too suddenly, or don't stop quickly enough, something will usually happen. On the other hand, some of the drivers near you may be just as inexperienced as yourself. So don't take it for granted they are going to do the right thing at the right time;

don't trust to them, but assume that every one is going to do the *wrong* thing; magnify the dangers rather than minimize them; be sure *you* are in the right, and then, if anything happens, you cannot be blamed.

Of course, there are a lot of road hogs and a lot of dare-devil reckless drivers in the cities as well as elsewhere, but that's no reason you should emulate them. Don't lose your temper; if you are caught in a blockade, or held up at a crossing when you're in a hurry, be patient. Getting angry or excited will not do any good, and it will divert the attention that should be given to driving the car. If another driver crowds his car in ahead of yours, if he dashes past with less than an inch to spare, if he bawls at you to move along, or makes uncomplimentary remarks about your driving, just ignore him, or smile and keep your mind on your own business.

If there are traffic officers or semaphores upon the streets, watch them and obey them implicitly, and don't get out of patience with a traffic officer if he makes a mistake or becomes irritable or confused. Remember these men have a most difficult, nerve-wracking, and tiresome task, and as long as you obey them to the letter you are on the safe side. Take things quietly, and don't try to hurry too much. If you intend to stop, hold out your hand—or have one of your companions do so—in order that others behind may know your intentions. If you are about to turn, indicate which side by your hand, and then make sure the following vehicles understand your signal before you turn or stop. If you are about to draw up at a curb, don't swing in suddenly, for there may be a car just behind you, but edge gradually to the side of the street, signal your intention, and stop as close to the curb as possible without scraping your

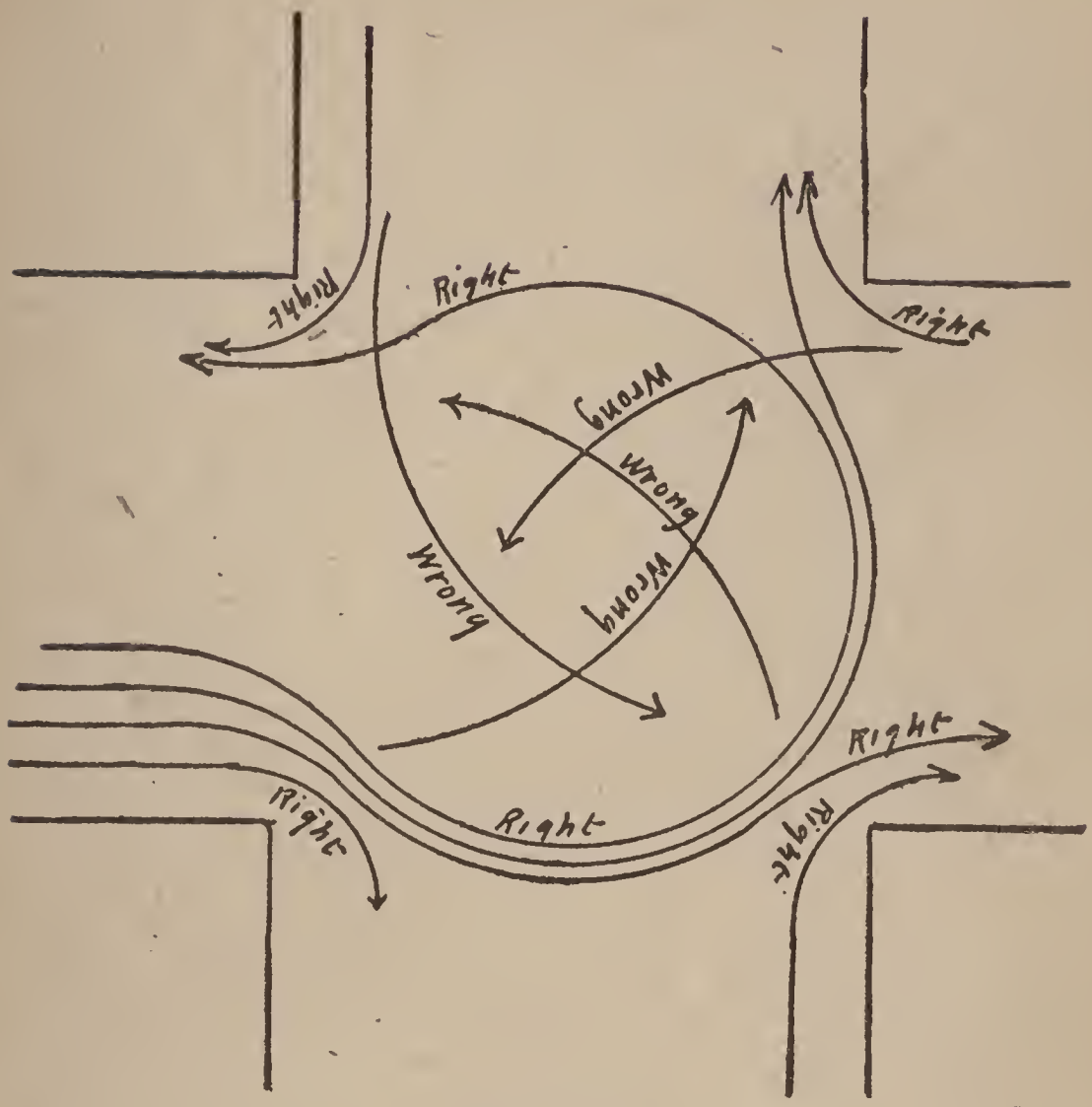


Fig. 23

FIG. 23—Circular traffic.

wheels. Don't cut corners diagonally, don't stop beside or within twenty-five feet of a fire hydrant or a fire-engine house, and don't draw up in front of a church, hotel entrance, or theater entrance unless you are merely stopping a moment to allow passengers to alight. Watch out for signs denoting one-way traffic on certain streets, and also for signs or lights denoting circular traffic. Circular traffic *(Fig. 23)* means that all vehicles must turn to the right or must travel in a circle or semicircle, and

while such spots are usually indicated by signs bearing arrows, or by green or blue lights, yet oftentimes there is nothing to indicate the rules aside from the signals of the traffic officers. Don't attempt to speed or to drive fast in a city, even where there is comparatively little traffic. Speed has no right in the city, and ten to fifteen miles an hour is about as fast as one can drive with safety or as the law allows. In spots where the traffic is congested, or when approaching corners where there are many pedestrians, reduce your speed so that the car can be brought to a full stop within its own length or even less, and blow your horn at every crossing, at every corner, and whenever you are about to overtake another vehicle.

Although, when navigating traffic, you must frequently stop and start, don't proceed by a series of abrupt stops and short dashes. This is hard on the car, the tires, and the engine, and is very unsafe. Don't speed up close to the car ahead and slam on the brakes, but glide up easily with clutch thrown out, or slipping slightly, bring your car to a standstill by a steady, gentle use of the brakes, and don't stop too close to the car ahead. In the first case, a sudden stop not only wears out your car and tires unnecessarily, but if the brakes fail or the wheels slide, you may crash into the cars ahead, while the following car, not knowing you are going to stop so abruptly, may crash into you. If you slow down and glide forward the stream of traffic may be in motion again before you come to a standstill, and it will not be necessary for you to stop or shift gears. If you stop too close to the vehicle ahead there is always danger of the driver of the other car backing slightly and smashing your car and his own. Always bear in mind that your car will

never stop twice in the same distance; a slope in the road, a hollow, a spot of oil or water, a fruit skin, a heavier or lighter load in your car, and a thousand and one other items all affect the distance in which a car can be stopped, and it is no use in trying to gauge the distance by inches.

Be very cautious when overtaking and passing other vehicles, especially large trucks, busses, et cetera. Never pass them when they conceal a corner or cross street ahead. You never can tell if another car is approaching and hidden by the vehicle ahead, and you should always sound your horn, slow down, and pass the other vehicle on the proper side, which is the *left*. If a bus or trolley car slows down or stops, don't pass it, but slow down and come to a full stop several yards behind it, and stay there until the car starts forward again, unless there is a "safety zone" or a traffic officer beckons for you to proceed.

Always remember that pedestrians *always* have the right of way over *all* vehicles. The streets and roads were not made for the exclusive use of motor cars. Don't sound your horn and keep on as if ordering the pedestrians to jump out of your path; sound your horn, slow down, and, if necessary, stop until the way is clear. Never pass trolley cars on the left, and if you are driving on car tracks remember your wheels may slip, and make due allowance in stopping. Bear in mind, too, that a trolley car can stop much more quickly than your car, and allow plenty of space between it and your car.

Don't take chances, even if you see other drivers doing so, and *don't* try to imitate the taxi drivers. These men are probably the most expert city drivers in the world, and their low-geared cars are under perfect control.

Besides, they constantly take risks and violate every rule of common sense and traffic as though they bore charmed lives. Make it a point to think out emergencies and problems ahead of time. If you are approaching a corner, always assume that another car is about to dash into view, and be ready for it. If you are nearing a cross walk where there are pedestrians, assume that some one is going to fail to hear your horn, or is going to become confused and step directly in your path, and be ready to act accordingly. Then, when the expected *does* happen, you will be ready and will act instinctively.

Imagination is a very valuable asset to the driver of a motor car, especially in traffic; for if you always imagine a thing is going to happen, if you imagine just what you will do in an emergency, if you imagine that the other fellow is going to do the wrong thing, then the chances are ten to one that when the trying situation arises your imaginary actions will become realities, and what you have planned to do in your imagination will be done mechanically.

The six great factors in driving, especially in a city, all begin with the letter C, and if you bear these in mind you can't go far wrong. They are: Control, Capability, Caution, Care, Consideration, and Confidence.

ACCIDENTS, THEIR CAUSES AND PREVENTION

With the enormous increase in the use of motor-driven vehicles the number of accidents has also increased by leaps and bounds, and unfortunately the majority of these accidents are avoidable.

In fact, broadly speaking, all but one or two classes of accidents are avoidable. These are, when a driver is stricken suddenly ill or dead at the wheel, when an accident occurs through some part of the car giving way, or when an accident results from a runaway horse or other outside cause. Even such accidents are, as a rule, avoidable.

If a man is subject to sudden fits, apoplexy, heart failure, or any other trouble which may render him helpless without warning, he should not attempt to drive a car; if a car is being driven at moderate speed, if it is regularly inspected and cared for, and the driver is familiar with its mechanism, a breakdown will seldom result seriously, if it occurs at all. Then, too, if horses were properly hitched they will seldom run away. But even admitting accidents of these classes to be unavoidable, they form but a very small percentage of the total number of motor-car accidents, and are perhaps the rarest of all.

Probably the greatest number of accidents are due directly or indirectly to speeding, and *every* accident of this sort is avoidable, and the offending driver should never go unpunished.

If we analyze the matter still further, we will find that

every accident, aside from those which I have mentioned as really unavoidable, can be traced to incompetent, ignorant, careless, or inexperienced drivers. This may sound like a mighty broad statement, but let us consider the matter, and see if it is not so. Practically all motor-car accidents may be classed under fifteen headings:

First—those due to speeding. Second—violation of rules of the road and traffic regulations. Third—skidding. Fourth—failure to sound warning signals. Fifth—failure of brakes. Sixth—disregard of others' rights. Seventh—getting "rattled." Eighth—mechanical troubles. Ninth—intoxication. Tenth—tire troubles. Eleventh—running without lights or with inefficient lights. Twelfth—carelessness or inexperience. Thirteenth—sudden illness or death of driver. Fourteenth—children suddenly running in front of machine, falling when roller skating, stealing rides or fooling with a car left standing unattended. Fifteenth—outside causes, such as runaways, explosions, falling trees, fires, et cetera.

All accidents in the first class are avoidable, and are due to incompetent drivers, for only an incompetent driver will travel at such a rate that an accident due to speeding can occur. In the second class, accidents are manifestly avoidable, and are due to careless or reckless driving. The third class is the same, for a competent and careful driver will use chains to prevent skidding, or will keep his car so well under control that a skid will not result in an accident. Those of the fourth class are equally avoidable, for no driver worthy of the name will fail to sound warning signals, and, even if he did, if his car is not moving too rapidly for safety an accident would not occur. The same is true of accidents due to failure of brakes, for the competent driver will see that

his brakes are in good condition, and, moreover, he will not permit himself to get into a situation where a failure of the brakes will result in an accident. Disregard for others' rights is criminal, and should be punished. No man should drive a car who can get "rattled." Mechanical troubles seldom occur if the driver is competent to look after his car, and, if not speeding, a mechanical fault will seldom result seriously. No man who ever drinks to excess should be permitted to drive a car—a drinking man is an incompetent driver. Tire troubles will not cause an accident if the car is traveling at a sane rate of speed. Only an inexperienced or incompetent driver will run without lights or with poor lights. The twelfth cause speaks for itself. The next I have already passed on, as I have on the last. In the case of children falling in front of a car, stealing rides, fooling with a standing car, or dashing suddenly under the wheels, there are times when, no matter how cautiously and slowly a car is proceeding, such an accident may happen. But if a car when left standing has its brakes set, and is turned against the curb and the switch is locked, it is seldom possible for a child to start it, and as a rule accidents to children may usually be traced to carelessness, or too much speed, on the driver's part.

Of course, it may be argued that speeding, in itself, is not due to incompetent or careless drivers, but as a matter of fact, speeding *is* due to ignorance or incompetency or intoxication, and nothing else. A really good driver, a man who possesses a thorough knowledge of his car, and who has any regard for others' rights, will not travel at an excessive speed. A man's ability to race his car across the country, or to tear madly through cities and towns, does not prove he is a good driver, for any

one who can handle the steering gear and wishes to risk his own life and the lives of others can run a car as fast as its mechanism will permit; but if he does so he should be treated as a dangerous criminal. Skill in driving is not measured by the number of miles an hour you travel, but by your freedom from accidents and near accidents. It takes far more skill to guide a car through traffic, to tour across country at a moderate speed, and to hold a clean record, than it does to drive madly for a few miles. The man who burns up the road is not a good driver, except for the race track, for the very first essential to a good driver is caution, and the speed maniac is never cautious. There is, I admit, a very strong temptation to put on more and more speed when a car is sailing smoothly along a straight and level road and there seems little danger in "hitting her up" a bit. But this is one of the greatest mistakes in motoring, for every mile that you add to a reasonable speed adds to the danger of something happening, and if anything *does* go wrong its consequences are magnified a hundredfold. A very slight accident to the mechanism, a puncture, or a blow-out, which might be of no consequence if the car was traveling at thirty miles an hour, might result in a complete wreck and loss of lives if the same thing occurred when going at sixty miles. Even a small obstacle in the road, a rut, a patch of sand or mud, which would not be noticed at a moderate speed, may overturn or wreck the car if it is traveling at an excessive rate. Moreover, the strain and wear and tear on engine, car, and tires increases out of all proportion to the increased speed of a car, and, if only for this reason, you should never travel beyond a safe and reasonable limit. Then, too, the question arises as to what *is* a safe and reason-

able limit. It is impossible to set any definite limit in miles per hour, for cars vary as to the speed at which they can be safely driven, and the drivers' abilities vary more than cars. It would be ridiculous to attempt to drive a light, cheap car at a speed which might be perfectly safe for a powerful, high-priced car, and it would be equally foolish for a newly-fledged driver to speed up to what might be a safe limit for a driver of long experience. The only safe rule to follow is *never to drive your car at such a rate that it cannot be brought to a full stop with one set of brakes within the clear space of road before you, or within a distance of two hundred feet on a level, open road. Never approach a corner or cross street so rapidly that you cannot come to a full stop by one set of brakes before you reach the corner, and never drive through traffic or behind another vehicle at a speed greater than will enable you to come to a full stop within ten feet.*

If you *must* speed, by all means go out alone, and the sooner you break your neck the better; or else take to the race track, and become a professional racer, where you can satisfy your desire for speed without endangering the public.

Next to speed, the greatest cause of accidents is in taking chances; the pedestrian takes chances, the driver takes chances, the trolley cars take chances, the horse-drawn vehicles take chances, and the wonder is that there are not more accidents. Even accidents directly traceable to speed are primarily due to taking chances, for the speed fiend takes the greatest chances of all. So, above all things, don't take chances; you may escape accidents by the narrowest margins for months, you may be lucky and escape your fate for years, but sooner or later,

if you take chances, some day chance is going to take you, and it is no use gambling with life and death. Ignorance also is a prime cause of many accidents, and by this I do not mean ignorance in driving, but ignorance of the dangers which exist. Modern cars are so well built and reliable, and are so easily controlled, that many drivers cannot realize the perils which are latent and may be suddenly developed by unskillful or careless handling. It is impossible to construct any mechanical device which will not break or fail at times, and while, under normal conditions, such a break or failure may be of no great importance, yet if the machine is overloaded, if it is being strained or is being overdriven, a slight break may cause most serious results. Such accidents cannot be foreseen, although if the car is properly cared for and inspected the chances of their occurring will be reduced to the minimum, and there is no fun in motoring if you keep your mind filled with dismal forebodings of what *might* happen. The percentage of such accidents is very small, and if you drive cautiously, and at a reasonable speed, the danger will be negligible. But there are plenty of perils which may be foreseen and guarded against, and foremost among these is skidding.

There are various classes of skidding, but in common terms, any slippage of a car's wheels, either sideways, forward, or diagonally, is termed skidding. The causes of skidding are manifold, but as a rule they are wet, oily, greasy or slippery roads, street-car rails, or soft sand. These may perhaps be more properly termed the *natural* causes, for even on a smooth, dry road a machine may skid if being driven too rapidly when a turn is made or the brakes are applied suddenly. The worst feature of skidding is that one never can tell when or how a car

may skid, for there are innumerable factors which influence skidding, and these are never twice the same. The condition of the road, the kind of tires, the extent to which they are inflated, the weight of the car's load, the speed, the gradient of thread, the distribution of weight, the way the brakes are used—all have a direct bearing on skidding, and the only safe way is to take no chances. You may drive for miles on a wet pavement and have no trouble; then, within the next block, you may skid without warning and wreck your car. If there is any chance of skidding, use chains, and never apply the brakes suddenly, for if the wheels are locked they must slide or slip, and no driver in the world can tell just how far or in what direction that slip is going to occur. A straightforward slip on a dry road is usually more injurious to tires than anything else, but if a car really skids or slues to one side very dire results often follow. Such side slips, or true skids, happen in the fraction of a second, and it requires lightninglike thought and action, a cool head, and great skill to overcome or check such a skid.

If both wheels of the car had exactly the same adhesion or traction on the roadway, if the brake bands exerted exactly the same grip and friction, and if the surface of the road was absolutely uniform, a skid would seldom or never occur. Unfortunately such an ideal condition of affairs is impossible of attainment, and hence side skidding is bound to occur. There are many causes of skidding of this sort, and very often several minor causes combine to produce a skid. An unequal air pressure in the two tires, an unequal distribution of weight in the car, wheels or axles out of alignment, worn or unevenly adjusted brakes, a jerking clutch, loose steer-

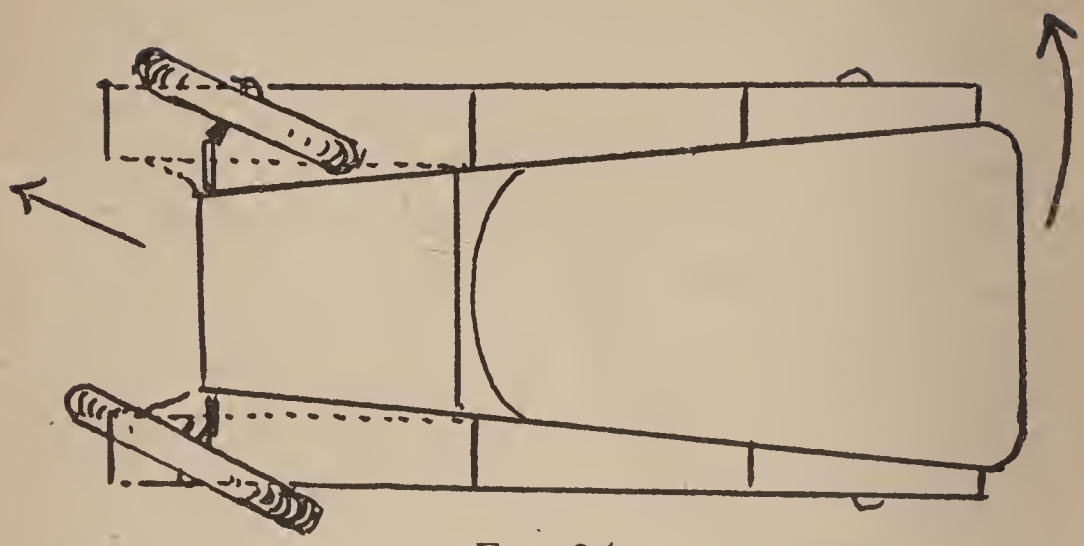


Fig. 24

FIG. 24—Rear-wheel skids.

ing gear, a worn or loose differential, an excessively crowned road, unevenly wet surfaces of the road—all are prime factors in skidding. Some cars appear to have little or no tendency to skid, while others are confirmed skidders, and will slue around at the least provocation. Fortunately rear-wheel skids *(Fig. 24)* are far commoner than front-wheel skids *(Fig. 25)*, for the latter

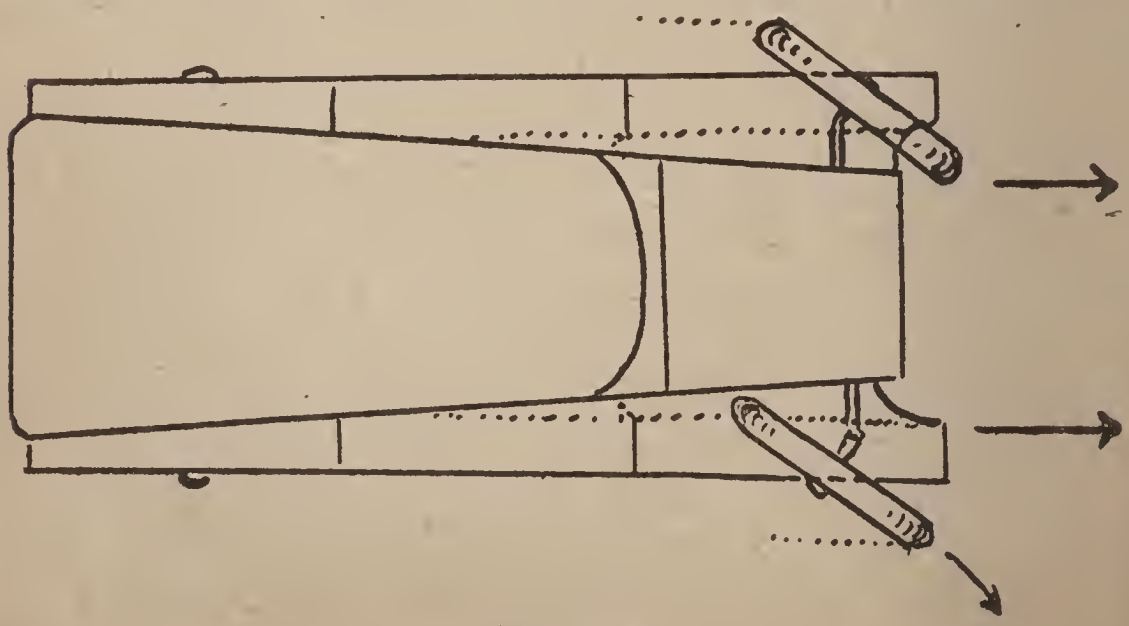


Fig. 25

FIG. 25—Front-wheel skidding.

are far more dangerous and difficult to overcome than the former.

As I have before mentioned, the best way to prevent skidding is to use chains, and if every driver made it an invariable rule to use chains whenever there was water, ice, mud, snow, sleet, or oil on the road, there would be few accidents from skidding; and it would be a mighty good thing if there was a law compelling the use of chains, or if lack of chains was considered evidence of criminal carelessness when an accident occurred through skidding on a wet pavement.

As a rule, chains on the rear tires are sufficient, while one chain on a rear wheel and another on the opposite front wheel will often serve even better; but if there is deep snow, ice, deep sand, or mud, chains should be used on all four wheels. Even rope is far better than nothing, and in sand or snow it often serves better than chains. But there are times when you may be caught without ropes or chains, or where there is a wet surface for a short distance only, and hence every driver should be prepared for skidding, and should understand how to act and what to do to check it when it happens.

When a car suddenly swings around to one side, there is an almost irresistible temptation to jam on brakes and steer *away* from the direction in which the car is sliding. In reality this is the very *worst* thing to do. The right way is to steer *toward* the side to which the car is skidding, and apply brakes gently and by little dabs, not with a steady pressure. In other words, if the car skids to the right, steer to the right; if to the left, steer to the left. By doing this the traction of the front wheels is increased, allowing them to guide the car, and at the same time counteracting the lateral slip of the rear

wheels. For example, if a car's wheels are sliding to the left and the front wheels are turned toward the right, the car will swing completely around in a circle, or will shoot off to the left at a tangent, for the front wheels offer no resistance, and, for that matter, even aid in the skid. On the other hand, if the rear wheels are skidding to the left, and the front wheels are turned *toward* the left, they tend to throw the rear wheels back to the right, for in order to continue to skid the front wheels must be slid sideways. Thus, by steering to the side toward which the car is skidding, and lightly applying the brakes to check the wheels' motion, the car will resume its straight-ahead position, and may be brought to a standstill or under control. Don't attempt to correct the skid and apply brakes with the clutch engaged; throw out the clutch as soon as the car begins to slue, and let it in very gently and carefully as the wheels again straighten out.

Front-wheel skidding rarely occurs without some very good and obvious reason. In crossing or turning out of a wet or greasy car track, in rutty roads, in sand or mud, or when climbing a hill with too much weight in the rear of the car, a car is most liable to skid straight on, regardless of how the front wheels are turned. The only safe method to follow is to apply the brakes and straighten up the front wheels. Don't jam on the brakes and hold them there unless there is danger of crashing into something ahead, but give a sudden hard dab to the brake pedal, release it, and throw it on again, and unless you are driving dangerously fast, the car will slow down and the wheels will grip and steer properly. The idea of this method is to cause the weight of the car to pile forward on to the front wheels, and increase their traction, and if

the brakes are shoved on so hard that they lock the wheels, the chances are that a rear-wheel skid will result, and an upset or serious accident will follow. Another method which often serves very well in overcoming a front-wheel skid is to throw out the clutch, accelerate the motor, and let in the clutch with a little jerk; but this is a strain on the motor and car, and should only be used as a last resort. Quite another type of front-wheel skid sometimes occurs when turning a corner. In this class of skid the front wheels slip sideways, and the whole car slides across the road. This is usually caused by taking the corner too rapidly, and, in a way, it safeguards the car and its occupants, for if it did not occur the car would in all probability capsize. It is extremely dangerous to other people, however, and the only way to avoid it is to take corners slowly, with the clutch thrown out or slipping slightly. In skidding, as in most things, prevention is far better than cure, and the best prevention is chains.

Many very serious accidents occur at railway and trolley crossings. Here, to take a chance is almost suicidal, and no motor driver should ever cross a railway or trolley track without slowing down, looking up and down the track, sounding his horn, and, if necessary, stopping his car to listen for sounds of an approaching train or car. *Don't* assume because no train is due, or there is no danger signal, that a train is not coming. There are such things as specials and extras, and signals often fail to work, while watchmen sometimes drowse or forget. If there is a long stretch of track within view, it is easy enough to see if anything is coming, but the best and safest plan is to STOP, LOOK, LISTEN before going on. Driving under bridges, especially where there is a

sharp turn or a blind crossing, is also very dangerous, for the noise of cars or traffic overhead may deaden the sound of an approaching motor car's horn. Go slowly, sound your horn steadily, and hug the right-hand side of the road as closely as possible.

Don't ever attempt to cross a small, flimsy-looking country bridge on an unfrequented road without examining it carefully. If it appears strong enough to support your car, let your passengers get out, and then run over it at a fairly good speed; the longer the car's weight is on the structure, the greater the strain, and many a bridge which can safely be crossed at fifteen or twenty miles an hour would give way if you crossed it at three or four miles an hour. It's like skating on thin ice—the more quickly you get over it, the less chance there is of going through; but don't risk your passengers by attempting it; let them walk over first. If the bridge doesn't appear strong enough to cross, either ford the stream, find another road, or reënforce the bridge by poles, fence rails, or posts. Always carry an ax when touring for long distances, for you never can tell when it will come in handy.

If you are obliged to ford a stream, and you will be if you do much touring in unfrequented districts, don't dash through it without investigating. Be absolutely sure of the depth, even if you have to wade across to find out. It is very unpleasant to attempt to cross a stream, and when in the middle, find that the water is above your floor boards, and that your carburetor and motor are under water. Besides, it is embarrassing to sit helpless with your feet on the seat cushions and wait for some farmer to arrive and haul your car ashore.

If the water is not too deep and the bottom of the

stream is firm, you may attempt to run across, but don't go through at full speed with a shower of spray drenching car and occupants. In the first place, it is a tremendous strain on the car, for water acts like a solid body to a swiftly moving object, and mud guards and radiator may be torn away by the resistance. In addition, there is always the danger of hitting a rock, snag, or hole in the bed of the stream. Ford the stream slowly and carefully on second, or even on first, gear, and the pressure of the water will be reduced, your car will be under better control, the spray will not be thrown over your passengers, and you will not have to shift gears to climb out on the opposite bank. If the bottom of the stream is of sand, clay, slippery stones, or mud, don't attempt to cross until you have put chains on the wheels, and remember that the bottom may be hard and firm to your feet and yet may not be hard enough to support the car; test it with a stick or pole pushed into it.

Another danger which should be guarded against is fire. If your car is well cared for, there is little danger of fire, for nearly all fires in motor cars are due to leaky fuel tanks, carburetors, or fuel pipes. If there is any gasoline leak on the car, a loose electrical connection, poor insulation on a wire, crossed wires, a short circuit, a blow-back in the carburetor, or a carelessly dropped match or cigarette may easily cause a fire. The best way to extinguish a fire is to use a fire extinguisher, but if you do not carry one you should smother the flame by a coat, robe, or cap, or throw fine sand or dust on the fire. Dust or sand is injurious to the carburetor and mechanism, but it is not half as injurious as fire, and after the flames are extinguished the sand can be cleaned out before the engine is used. Remember that *gasoline floats*

on water, and that to use water when the fuel is burning will merely spread the flames and make matters worse. But if there is *no burning gasoline,* water may be used to advantage.

I have already mentioned the dangers of hills, and I can only add one bit of cautionary advice, and that is: if your car *does* become unmanageable on a hill, and there is no hope of controlling it, have your passengers scramble out *at once.* They may be bruised and cut, but that is better than being killed or badly injured. Moreover, after the car is relieved of its load you may be able to check it, especially if your passengers can hold on to it. Then, if still beyond control, jump out yourself and let the car go; you will lose your car, perhaps, but you will probably save your life. Jump from the opposite side toward which the car is going, and jump *downhill.* If possible, select a smooth or soft spot, and unless you land in a mass of rocks or leap over a cliff, you will probably escape with torn garments and grazed hands and knees. It is all right to stick to your ship, but the sensible mariner or car driver is the one who knows when sticking becomes suicidal and acts accordingly.

RULES AND REGULATIONS

It may seem superfluous to devote any space to rules of the road and traffic regulations, but a great many accidents and innumerable arrests and fines are the direct results of violating rules and regulations that should be familiar to every operator of a motor vehicle.

Of course many violators of these rules *are* familiar with them and deliberately disobey them; but there are also many drivers who do not intend to violate the regulations and get into trouble through ignorance.

Everywhere in the United States, the universal rule is: *Keep to the right-hand side of the road; pass approaching vehicles on the right and pass overtaken vehicles on the left.* In most foreign countries and in Great Britain, Canada, and all British possessions the rules are exactly the reverse, and you should *keep to the left-hand side of the road, pass approaching vehicles on the left, and pass overtaken vehicles on the right.* This is apt to be very confusing when you first drive in a British country, but you soon become accustomed to it.

While these rules apply in general, there are many regulations and ordinances in cities, towns, boroughs, et cetera, which are just as important and which in many cases conflict with the ordinary rules of the road. Thus, in many cities motor cars must *not* pass overtaken trolley cars on the left, but must keep to the *right;* and in many towns and cities vehicles pass others going in the *same direction either on the right or left.* In turning corners, too, the usual rule is to swing around in a half circle and keep to the *right-hand* side in the direction you are

heading; but in many cities and towns you are compelled to cut *diagonally across.* This is the case in New York City, where there are semaphores and where cars must approach the traffic officer in the center of the street and turn in front of him when going to the *left;* while in other places you are supposed to go *around* the officer and behind him when swinging to the left. In some cities it is even more confusing, for one officer will compel you to turn in one way and the very next officer will expect you to do just the opposite. It is also difficult to learn just what the officers' signals mean, for their gestures are often of such an indefinite character that it is impossible to say whether they are beckoning you to go ahead or are warning you to stop. As a general rule, however, if the officer stands facing you or with his back toward you, traffic is closed in your direction; whereas if he stands sideways to you, you may proceed. But quite often an officer will stand sideways and signal you to stop, or, while facing you, may signal you to go ahead. If you have the least doubt as to the gestures or signals, stop and wait until you are sure he is ready for you to proceed. It is the safest way. Always go slowly and cautiously until you are positive you know all the regulations and rules, and stop and ask some traffic officer about the local regulations if you are in a new or strange town. This is quite essential, for there are innumerable rules regarding cars left standing in certain districts, the use of certain kinds of lights, the use of horns, speed, one-way and straight traffic, et cetera. If you make a mistake through ignorance, the law will hold you responsible, for ignorance of the law is never an excuse for disobeying it. Unfortunately, this variation in rules and laws regulating the use of motor vehicles is the cause

of many accidents and much trouble, and it is a great pity that uniform laws are not everywhere in force. There are far too many conflicting rules, and many of them are ridiculous, obsolete, and inadequate, while others have become a dead letter and are seldom enforced. But motorists already have a bad enough reputation as law-breakers without adding to it by violating rules, no matter how foolish or petty they may be; and there is no question that many motorists fully deserve the unsavory reputation they have, for they are guilty of the most barefaced, gross, and flagrant violations of law and common sense, and as a result the innocent suffer for the guilty; for to the average policeman and the public all motorists look alike.

The officers in the large cities are usually a good-natured, efficient, and courteous lot, and if they see you are from another State they will often go out of their way to warn you of local rules, or will overlook unintentional violations, or will stop you and caution you not to repeat them. But the country constables and rural police consider all motor vehicles and their drivers—especially strangers—as legitimate prey, and will be only too glad to summon you to court and mulct you of a goodly sum for some trivial and wholly unintentional violation of local ordinances.

So, no matter what the other fellow does, obey every law, rule, and regulation; and if in doubt, *stop*. If the other chap wants to take a chance of getting into trouble, let him; but don't follow his example. Then don't forget that officers are human and that all human beings make mistakes. Don't talk back or discuss matters with a traffic officer, even if you know he is wrong and you are right. It will do no good and will give him a chance to

arrest you, and in court *his side of the story goes.* Take everything good-naturedly, and remember the line: "Laugh and the world laughs with you." But *don't* laugh at some pompous policeman or self-important constable; take them seriously and be sufficiently impressed until out of their sight or hearing.

Also bear in mind that pedestrians have the right of way over *all* vehicles, and that if a pedestrian sees fit to stand in the street or to walk in the highway it is no excuse for running him down. For all you know, he may be deaf, crazy, or drunk, and it is just as serious a matter to kill or injure an imbecile, a deaf man, or a drunkard as it is to run over a millionaire or a bank president.

Remember, too, that the plodding farmer's wagon has the same rights to the road as yourself, and that horses and carriages were using the highways long years before motor cars were dreamed of. Don't sound your horn and tear on, expecting the horse and team to haul aside instantly; for even if the driver gives way he cannot move as rapidly as a motor car, and if he has a heavy load it may be impossible for him to turn out until he finds a suitable spot. Always give a horse or a horse-drawn vehicle plenty of room; turn aside for it, if necessary, and if the animal shows any signs of fright, slow down or stop until he passes or until the driver dismounts and takes the creature by the bridle. In many States this is compulsory, but, even if it is not, common respect for life and limb and common courtesy should compel it.

Always put yourself in the position of the pedestrian or horseman and consider their rights and safety before your own; obey the laws, no matter how foolish they seem; have patience with the police and constables; run

slowly and carefully; ask questions when in doubt, and use common sense, and you will seldom or never come into disagreeable contact with the law.

If through any reason an accident *does* occur, don't try to shift the responsibility or shirk your duty, even if it *was* the other fellow's fault. Stop your car at once, give your name and address, and render all possible assistance to the injured. If an accident occurs on a country road, or where police and ambulances are not at hand, hurry the injured person to the nearest doctor or hospital and leave your name and address. If your car is injured so that it cannot be used, telephone to the nearest police, to the doctor, or to a hospital, and then remain at the scene of the accident till help arrives. If there is no telephone within reach, run to the nearest house or stop some passer-by and send the message.

In nearly every State and city such actions are compulsory by law, and if you fail to comply with the rules the fact will be considered as evidence against you; but no law should be required to make you do all in your power to aid the victim of an accident. Common decency and humanity demand it.

Finally, let me suggest that before you start on a tour or a trip it is an excellent plan to obtain copies of the motor-vehicle laws of the States through which you expect to travel. In many of their most important features they are alike, but they vary greatly in many particulars. By addressing the proper authorities of the various States, copies of the laws may be obtained. This course will save you a great deal of trouble and inconvenience and may save you a still greater amount of time and money.

FIRST AIDS IN EMERGENCIES

A great many motorists seem to think that their equipment of tools is of no importance, and they start on long tours with a few poor, cheap, rusty, and worthless tools that might just as well be thrown in the junk pile. Of course a great many of them "get by," and by some miracle they succeed in running for a long time without requiring tools; but sooner or later something will require adjusting or repairing, and the car is held up and unnecessary expenses are incurred merely for the lack of a few good tools and spare parts.

Money invested in good tools is never wasted, and, while it is not necessary to spend a large sum on tools for the car, nor to carry a machine shop or hardware store on your travels, yet your tool box should contain all the essential tools and spares to enable you to make any minor repair on the road. Such tools as you have should be of the very best quality. Poor tools are as bad as none, and a poor tool is never cheap at any price.

The exact tools and spares you will need will depend largely upon your car, the distance you are going, and your own ability as a repair man; but the following should be ample for all ordinary uses, even on long cross-country tours:

A good, serviceable jack.
Tire irons.
A hand pump.
Spark-plug wrench.
A hack-saw frame and blades.
A hub-cap wrench.

A machinist's ball peen hammer.

A small cold chisel.

A pair of serviceable slip-joint pliers.

A three-cornered and a flat file.

At least three good, strong, steel screwdrivers.

A Westcott or "S" wrench.

A small bicycle wrench.

A medium-sized Coe or monkey wrench.

A medium and a small-sized Stillson wrench.

A gimlet.

Any special tools, spanners, or wrenches to fit special nuts or other parts of your car.

A light, strong Manila tow rope at least twenty-five feet long.

Extra insulated wire.

A spool of soft copper wire, or annealed iron wire, about 20-gauge.

A few feet of large, strong iron wire.

A roll of good friction tape.

Assorted machine screws.

A few wood screws, carriage bolts, stove bolts, and nails.

Some patent solder to be used without a soldering iron.

Assorted cap screws and nuts.

Assorted nuts of the sizes and threads used on your car.

A couple of spring clips large enough to take the springs on the car.

A box of assorted cotter pins.

A box of assorted lock washers.

Some assorted taper pins.

A ball of stout linen twine.

An extra fan belt and fasteners.

Spare parts, such as balls for bearings, extra pins, yokes, and shackles for brake rods, et cetera.

Extra spark plugs.

A box of fuller's earth or powdered pumice.

A box of cup grease and a can of oil.

Extra inner tubes with a repair kit of cement, patches, et cetera.

A folding pail.

This sounds like a long list, but many of the items are small and all may be stowed in an ordinary tool box or under a seat; and while you may go for months and never need half of them, yet when you *do* want them you will want them mighty badly, and you will be thankful you carried them. With this outfit, almost any ordinary repair may be made on the road; but unless you know your car and know how to use the tools, they might just as well be left at home.

It is impossible, in the space of this book, to describe how to use the various tools or to mention the innumerable emergencies which may call for their use, but the following suggestions will perhaps help in getting out of troubles by short cuts and for rendering first aid to your car in case of need:

GRINDING VALVES

One of the commonest troubles with a motor is lack of compression caused by leakage around the valves. This is due to the valves and their seats becoming worn, cut, or pitted from the burned gases, and the only remedy is to regrind them. To grind in the valves is a very

simple and easy matter, and yet many motorists go to a great deal of expense to have their valves ground in at a garage, and very often the work is carelessly and improperly done at that.

The only tools and appliances necessary are a valve-lifting tool, a box of valve-grinding compound—or some fine emery and oil—and a screwdriver or valve-grinding tool. If the valves have slots, a screwdriver is used, whereas if they have two little holes a tool to fit them is required.

To grind in the valves, turn over the motor until the valve you are to grind is closed and free from pressure against its tappet. Remove the valve cap on cylinder head above the valve. Insert the valve-lifting tool under the spring on the valve stem, and, while holding up the spring, remove the pin, collar, et cetera, which holds the spring in place. Then carefully release the spring and lay the spring and parts of the valve at one side. Lift the valve from its seat, and you will find that the lower or beveled surface is black or dark colored and is probably rough and irregular. Place a little of the valve-grinding compound—or emery mixed with oil—on the beveled surface of the valve and valve seat, place the valve back in position, and with the screwdriver or valve-grinding tool press down firmly on the valve, and, while exerting a steady, uniform pressure, turn it rapidly back and forth on its seat. Lift the valve occasionally and turn it to a new position and continue rotating. As soon as you find the gritty feel of the valve has disappeared and it moves smoothly on its seat, remove the valve, wipe it off, and examine its surface and that of its seat. If a clean, bright surface shows uniformly all around, the valve is sufficiently ground; but if there are spots or

streaks of dull or black metal, the operation should be repeated until the entire surface is smooth and bright.

When grinding do not press down too hard, and be careful not to get any of the grinding compound into the cylinder or motor. Carefully wipe and clean the valve, the seat, and the interior of valve chamber with an oiled rag and see that all traces of the compound are removed. Then drop the valve into place, see that there is clearance between the end of valve stem and the tappet, replace the spring and fasteners, and the valve is done.

In many motors it is necessary to remove the cylinder heads in order to grind the valves, but the operation otherwise is the same. In most engines the exhaust valves require grinding far oftener than the intake valves, but as a rule the motor will be vastly improved if all the valves are ground at the same time.

ALIGNING WHEELS

Very often the wheels of a car may get out of alignment; or, in other words, they may be farther apart at the lower edge than the upper, or the forward edges may be farther or nearer together than the rear edges, or the front and back wheels may not be in the same line.

Such troubles may arise through wear, through slightly bent axles, through badly adjusted steering gear or radius rods, through springs being twisted or sprung, or through some injury to the chassis. It is an easy matter to determine if the wheels are out of line, but often much harder to remedy the trouble. It is, however, very important to keep all four wheels in perfect alignment, for wheels out of true will cause a car to steer badly, there is a greater

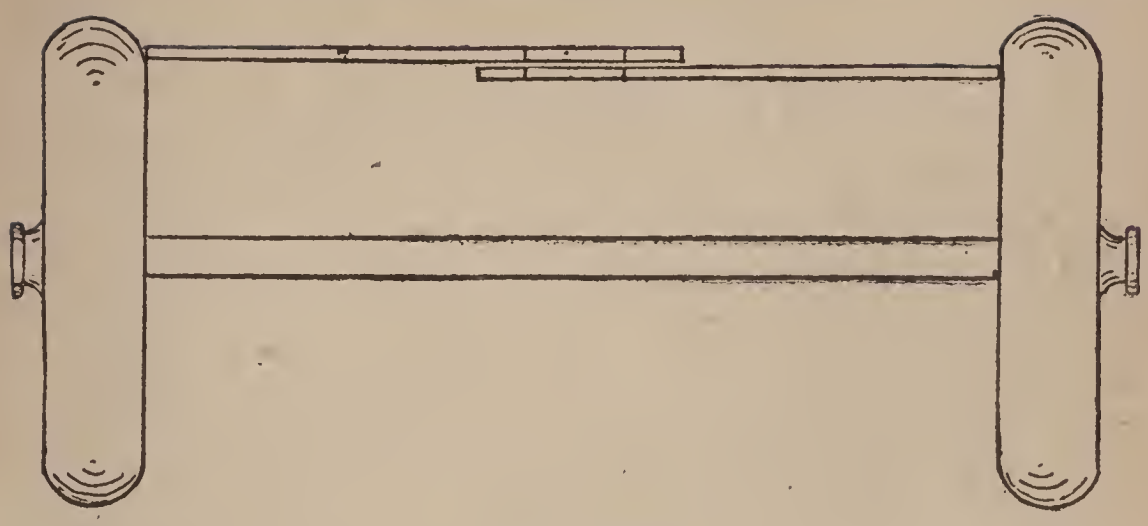


Fig. 26

FIG. 26—Aligning front wheels.

chance of skidding, and the wear on tires is tremendous. Luckily the front wheels get out of alignment more frequently than the rear wheels, for it is far easier to remedy the trouble. There are several methods of aligning wheels, but the following will prove very easy and simple: To align front wheels, turn them until one wheel is parallel with the frame and in line with the rear wheel on that side, which can be determined by means of line stretched across from front to rear. Have two light sticks or rods, each a little more than half as long as the distance between the wheels, and place one rod against the inner rim of one wheel directly in front of the hub and place the other stick against it and with its end bearing against the inner rim of the opposite wheel.

Mark a couple of lines across both rods, as shown in *Fig. 26,* and then in the same way measure the distance between the rims directly back of the hubs. If the front edges of the rims are farther apart than the rear edges, or vice versa, it will be necessary to adjust them by lengthening or shortening the cross rod of the steering

gear which connects the two front wheels. It is much more difficult to align the front wheels vertically, for the front wheels should be slightly farther apart at their upper edges than at their lower edges, and if they are not it shows that the spindles that support the wheels at the axle ends are worn or bent, or that the axle is bent. In the former case, the bearing of the spindles may be tightened up, if provided with an adjusting device, or new spindle bearings may be fitted; but don't attempt to tighten or adjust them with the weight of the car resting on the wheels; jack up the front axle so both wheels are clear of the ground. In case the axle or spindles are bent, the trouble should be remedied at once by having the axle straightened or by putting in a new spindle.

The alignment of the rear wheels may be accomplished in the same manner as for the front wheels, but the rear wheels should be the same distance apart at the top as at the bottom. If out of alignment either vertically or horizontally, the trouble may usually be corrected by means of the truss rods on the rear-axle casing; but if due to a bent axle or bearing, the defective part must be replaced with a new one.

Even if the front wheels are lined up correctly and the back wheels are parallel, the two sets may be out of alignment, or one or both sets of wheels may be out of alignment with the frame or chassis of the car. To determine this, take two straight bars or pieces of scantling a little longer than the extreme distance across the wheels from hub to hub—say five feet—fasten these at the height of the hubs, one in front of and the other behind the car, and both exactly parallel with the cross members of the chassis; stretch a cord from the extreme outer end of one bar to the corresponding end of the

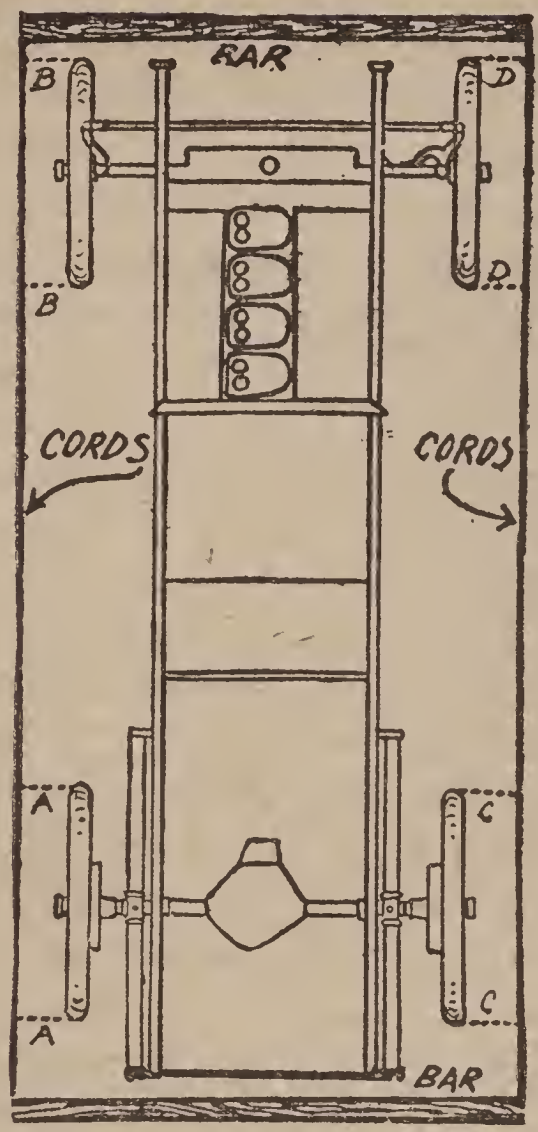


Fig. 27

FIG. 27—Aligning wheels with car.

other and carefully measure the distances from this cord to the rims, as shown at *A, A, B, B, Fig. 27.* If the distances, *B, B,* are not the same, turn the front wheel until it is parallel with the cord. Then measure off the distance, *A,* on the opposite ends of the two bars and stretch another cord between the bars at these marks. If the wheels are all in line and true with the chassis, the distances, *A, A, B, B, C, C, D, D,* will be alike; and if they are not, one or more wheels are out of alignment, and it

is an easy matter to determine where the trouble lies. It is still easier to find out if the front wheels are parallel with the rear wheels, for it is only necessary to stretch cords across the rims from front to rear, and the least deviation in alignment will be evident, but this method will *not* show if the wheels or axles are out of alignment with the frame.

BROKEN SPRINGS

Even the best of springs will break at times, and, while a single broken leaf, if in the center of the spring, will do little harm, and the car may be driven for long distances with care, yet if the outer or longest leaf is snapped, or several are broken, the car will be put out of commission until a repair is made. There are many emergency spring repairers on the market, but few motorists carry them as part of their regular equipment, and as a rule a very good emergency repair may be made by using ordinary carriage spring clips, which should always be carried, or which may be obtained at any country blacksmith shop. If some of the leaves of the spring are unbroken, a clip placed on each side of the break will usually serve to hold the spring until you reach home or a garage; but the clips must be set up tight and you must drive very carefully, with as much of the load as possible shifted to the other side of the car. If all the leaves are broken, a piece of steel or iron or an old spring leaf should be placed across the break and under the clips; and if two are used, one below and the other above, a very strong repair may be made. *(Fig. 28, A.)* Even a piece of hard wood clamped or strapped to a broken spring will serve in an emergency. If the top member of

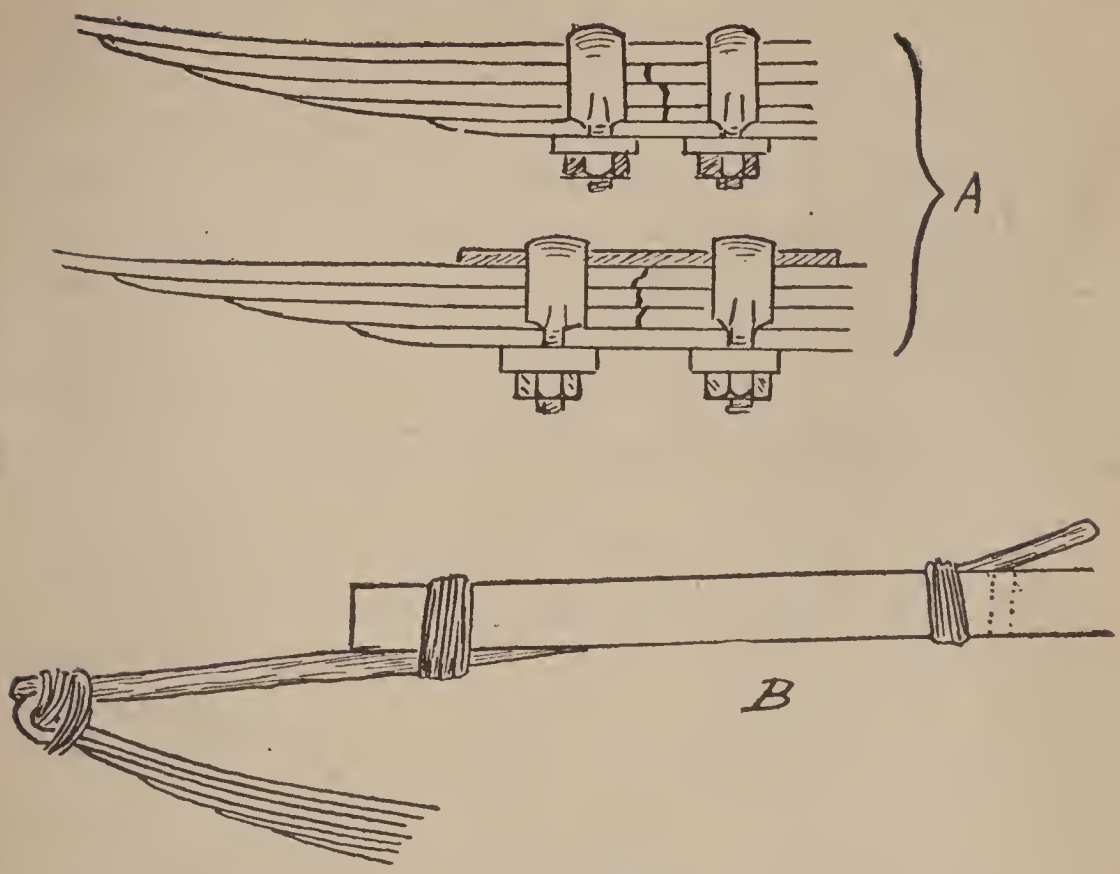


Fig. 28

FIG. 28—Emergency-spring repairs.

a semielliptic spring gives out, you need not despair of driving home or to a garage under your own power; for if the body is jacked up and a stout hickory or hardwood pole is inserted over a cross member of the chassis and is secured as illustrated in *Fig. 28, B,* the car may be driven for a long distance in safety. Of course the side where the makeshift is used will sag and groan, but if you have your passengers shift their weight to the opposite side and front and drive slowly and carefully you will have no trouble.

LEAKS

A very frequent trouble, especially on long trips over rough roads, is a leaky fuel or water connection. Leaks in the water system are much easier to repair than in the fuel system, for many substances which are waterproof are absolutely useless to prevent gasoline leaks. Adhesive rubber tape wound around a leak in a water pipe or hose will usually work very well, and if no tape is at hand some oil or grease-soaked rags tied or wired in place will serve very well for a short time. The best material for stopping leaks in water tanks, radiators, et cetera, is well-masticated chewing gum secured in place by friction tape, and very often a repair of this sort will outlast the metal itself. If the leak is in the interior of the radiator, a small amount of fine bran, cornmeal, or mustard added to the water in the radiator *while the motor is running* will usually stop the leak. Use only a few spoonfuls of the material, and add it to the water a little at a time. This will often stop a leak around the spindle of the water pumps also, but as a rule a leak of this sort requires new packing, unless the packing gland can be tightened enough to stop it. Cotton or hemp packing should be carried for this purpose, but if no regular packing is on hand, cotton twine, lamp wicking, a strand of rope, cotton waste, or the fine-shredded inner bark of cedar will do very well. Whatever material is used, it should be well greased before being placed in the pump.

Leaks in the fuel system, if small, may be stopped effectively by means of ordinary laundry soap rubbed into the hole or crack and wound with a rag. A more satisfactory repair may be made with shellac. Clean the surface about the leak, apply a good coat of shellac, and

let it dry; then apply a second coat, wrap a piece of cotton cloth about it, and let the shellac harden. Then give another coat over all, and, when dry, you will have a tight repair that will last for a long time. Leaky threads on gasoline-pipe connections may be made tight by rubbing with soap before screwing them up, and a turn or two of soft cotton cord or the strands of cotton waste rubbed with soap will often prove effective in stopping a leak due to badly fitted unions at the ends of fuel pipes. If there is a bad leak or a broken pipe, it may be necessary to solder it. Don't attempt to solder any portion of the fuel system until all the gasoline has been drawn off and enough time has elapsed to let all vapors disappear.

LOOSE NUTS AND BOLTS

These are often very troublesome, and it may be impossible to keep them tight if the threads are worn or stripped. Of course the best remedy is a new bolt or nut, but a badly worn thread may be made tight in an emergency by several methods. A fine silk or cotton thread wound around the threads will often do very well, or the threads of the screw may be burred or roughened a little. Slightly riveting or flattening the *top* of the hole in a nut will frequently serve equally well; and shellac, applied to the threads and allowed to dry before being used, will usually prevent a nut from working loose. If the nut, bolt, or screw cannot be tightened up until it does not rattle, it may be secured in position and prevented from moving and rattling by wrapping adhesive tape about it.

BRAKE TROUBLES

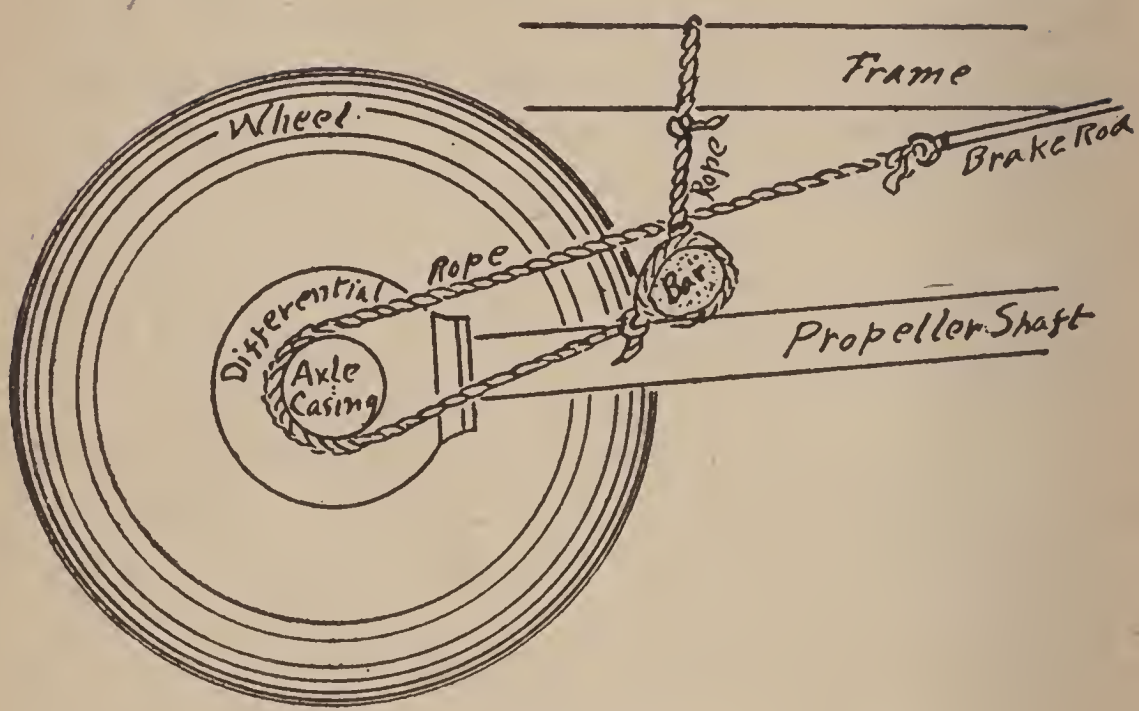


Fig. 29

FIG. 29—Brake substitute.

If brakes slip and cannot be adjusted to hold, they should be thoroughly cleaned with gasoline and then treated with fuller's earth, powdered pumice, or fine dust. Ordinary road dust will be injurious, but if sandy soil is stirred up with water and the liquid with the finest material in suspension is poured into a rag or handkerchief, a very fine grit may be obtained which will serve in an emergency in place of the fuller's earth. Resin will also serve, but this gums up the brake bands and is only advisable as a last resort. In case of the brakes giving out beyond repair, an emergency brake may be rigged up as shown in *Fig. 29*. This consists of a plank, pole, timber, or part of a fence rail long enough to reach across the car and project a few inches beyond the wheels on either side. Suspend this from the frame in front of the

wheels and above the propeller-shaft casing, as shown in the cut. Attach ropes, straps, or chains to the timber, bring them under and over the rear axle, and fasten the ends to the brake rods as shown, and the brake may be operated by the regular levers. A temporary brake, especially for supplementary use in descending hills, may be made by taking a turn of rope around the rear hubs, or placing a slipknot about them, and hauling the rope taut by means of an improvised lever. Of course such makeshift brakes are hard on tires and hubs, but worn tires or paint are of little consequence compared to running without brakes.

HOW TO START WITHOUT A CRANK

With the almost universal use of self-starters, the bugbear of cranking a car has been almost forgotten. But self-starters fail at times, and very often when they *do* fail the emergency crank will be found missing. But even so it is not difficult to start a car. If there is a hill or declivity of any sort, the car may be pushed to the brink, the throttle opened, the ignition switched on, and the gears put in second or third speed. Then, with the clutch thrown out, let your companions push the car over the edge of the hill, and as soon as it gathers way let in the clutch gently and the motor will start.

If you are alone and there is no one to shove the car on to the slope, or if there is no declivity available, it is still possible to start your car. Jack up one rear wheel, place blocks, stones, or some other obstacles in front of and behind the other wheels, open the throttle, switch on the ignition, put the gears in high or third speed, and

by revolving the jacked-up wheel the motor may be turned over and started. As the gear ratio between wheel and engine is all in favor of the latter, it requires considerable strength to crank a large motor in this way, and the greatest care should be used not to let your arm or hands get caught in the spokes of the wheel. *Don't* push forward on it, but stand as far from the wheel as possible, grasp the spokes near the *bottom* of the wheel *behind* the hub, and pull quickly and sharply *up* on them and release your hold instantly. A still safer plan, which will work very well on many cars, is to place the gears in high, open the throttle, keep the ignition *shut off,* and turn the motor over several times by means of the rear wheel. Then take your seat, place the gears in neutral, throw on the switch, and move the spark lever back and forth. If your motor is on a firing stroke and your ignition system is a battery with a timer or distributor, the motor will probably start. Whether it does or not will depend largely upon the ignition system used.

CLUTCH TROUBLES

If a clutch is properly cared for and adjusted, there is no reason why you should have trouble with it. The commonest trouble with a clutch is slipping, especially with a leather-faced clutch. In case this happens, the clutch should be washed with gasoline squirted in by means of an oil can while the clutch is thrown out, and a sprinkling of fuller's earth or powdered pumice should then be applied to the leather. *Don't* use sand or dust unless you are compelled to, and then use only the washed

fine material as directed for brakes. Resin is better than sand, however, and if you are in a district where there are evergreen trees, the gum from these may be gathered and pulverized and used with good results. The easiest way to use resin or gum is to dissolve it in gasoline and apply it with an oil can.

STEERING-GEAR REPAIRS

In addition to their value for repairing springs, spring clips are often handy for many other emergency repairs. Even a deranged or broken steering gear may be temporarily made serviceable by their use; for by clamping them over strips of hardwood or small rods or bars of metal, a cross rod, steering arm, or other part may be held together until the car can be driven to a garage or blacksmith shop. If the socket plug in the ball joint of the cross rod or reach rod drops out, it may be temporarily replaced by using a plug of hardwood driven into the tube and secured by wire and a nail. But *don't drive rapidly with any emergency makeshift on the steering gear.* Use second or even first speed, and *don't coast down hills!*

BACKING UP A HILL

Speaking of hills, there may be times when you cannot climb a hill even on first speed. This may occur through any one of several reasons, even if the hill is not very steep. If your fuel system depends upon gravity to feed the carburetor, or if the gasoline is low in a vacuum or pressure tank, the slope of the hill may prevent the fuel

from flowing through the pipes, owing to the carburetor being above the lowest point of the gravity tank, or the opening in the pressure or vacuum tank being exposed when the fuel runs back to the corner of the tank. But if your motor misses and stops for this reason, and you find it impossible to make the hill, don't be discouraged and prepare to walk several miles for fuel or to wait disconsolately for some other car to come along and help you out. If you are a good driver you can still guide your car safely up the grade by turning it around and climbing the hill *on reverse.* This may sound ludicrous, but it is a trick that has saved many a motorist from long delays and weary tramps. By reversing the car the fuel tank is made higher than the carburetor, if a gravity tank; or the fuel may be made to flow into the pipe, if a pressure or vacuum system; while the reverse gear, being the lowest ratio of all, gives even greater power for hill climbing than the low gear. The only trouble is in steering; but with such a low gear any ordinary driver should find little difficulty, unless the hill is very crooked and uneven.

REPAIRING SPARK PLUGS

If you make it a point always to carry extra spark plugs along you will save a great deal of time and trouble, for it is quicker to put in a new plug than to clean or adjust an old one; and if a plug is broken or cracked it is usually a waste of time to bother with it. At times bad luck will follow you, and you may exhaust all your extras and still have a cracked or broken plug. Shellac will serve to repair a cracked porcelain if the break is

outside the cylinder, but the heat soon destroys the shellac and such a repair will only last for a very short time.

Ordinary plaster of paris can be used if care is taken to have the plaster thoroughly dry and hard before starting the motor; but the best material is water glass or sodium silicate, which may be obtained at almost every drug store. This is not waterproof, but it will resist heat and is strong and a plug porcelain repaired with it will often hold for a long time.

BROKEN FAN BELTS

A spare fan belt, with fasteners, should form a part of your equipment if you are going on a long trip or through unfrequented districts; but in case you have none, a substitute may be made. Small rope, braided cord or twine, a strip from a waist belt, strips of braided cloth, a piece of a trunk or shawl strap, or even a piece of soft flexible bark or braided cedar bark or grass, will serve the purpose temporarily.

AXLES

Now and then an axle will snap without warning, and I have known of an axle breaking while the car was standing still; and if an axle does break, a new one must be obtained before the car can be used. But it is not always necessary to abandon the car on the road, for with the aid of a plank and some rope the car may be towed to a garage or repair shop. Jack up the car, place the wheel with the stub of the axle in place, cut a hole in a

plank to fit over the hub of the wheel, lash the plank firmly to the frame, and the car may be towed readily. The plank should be watched to see that it does not slip off the hub, and the car should be moved slowly and all load should be taken from it.

PULLING OUT OF HOLES

In most cases it is an easy matter to pull out of a bog hole, or out of mud, clay, or sand by means of tire chains, but it is often impossible to put on chains in such places. Under these conditions the "mud hooks" sold by all accessory dealers are the most useful appliances, and on long trips you should always carry a few along. If you have nothing of the sort, a rope wrapped around the rim and tire will often answer the purpose. Old rags, straps, strips of bark, or wild vines will also serve, and oftentimes very good results may be obtained by throwing stones, gravel, sod, sticks, or other material around and under the wheels. If necessary to jack the car up and the ordinary jack cannot be used, a sapling or a fence rail may be used as a lever by placing one end under the axle and using a log, rock, or box as a fulcrum. Sometimes, however, the wheels may be buried so deep that it seems hopeless to extricate the car without the aid of another car or a pair of horses and a tow rope. But if you have a good rope along with you, as you should have, you can pull out of almost any hole by the use of the rope and a little ingenuity. The first method is to make your car act as its own windlass. To do this, attach one end of the rope to a spoke of a rear wheel close to and below the hub, take a turn around the hub from

front under and back and over, carry the end of the rope forward and make it fast and taut to a strong tree, post, or rock. Then start the motor and throw in first speed. The wheel, in revolving, will wind the rope about the hub and will haul itself forward. The only difficulties that may occur will be that the free wheel slips and spins, or that the rope slips off the hub. In the former case, disconnect the brake rods from the wheel with the rope, set the brakes on the other wheel, and try again. If the rope slips off the hub and you have no companion to keep it in place, you must stop, shove on brakes to prevent the car sliding back—or chock the wheels if brake is disconnected—loosen the rope, take a new grip, and repeat the operation until you are out of the hole.

The other method is to rig up a "Spanish windlass." With this simple and ancient contrivance the heaviest of cars may be dragged from any hole or even up a steep bank, the only limit being the strength of the rope and the length of the levers used. Even an overturned car may be righted by one man by using this device, and every motorist should know how to make use of it.

The only things needed are a couple of strong pieces of wood, a good rope, and some firm fastening such as a tree, post, or rock. If none of these is at hand, a number of stout stakes may be driven into the ground, or a heavy log may be secured by wedging it behind rocks or small trees, or even by burying it in the earth with stakes driven in front of it. Fasten one end of your rope to the "anchor" and attach the other to the car. Then, with a bar of wood about six feet long, take a turn of the rope around one end, as shown in *Fig. 30, A.* Rest a shorter piece of wood against the first on the *side away from the car* and at right angles to the first piece,

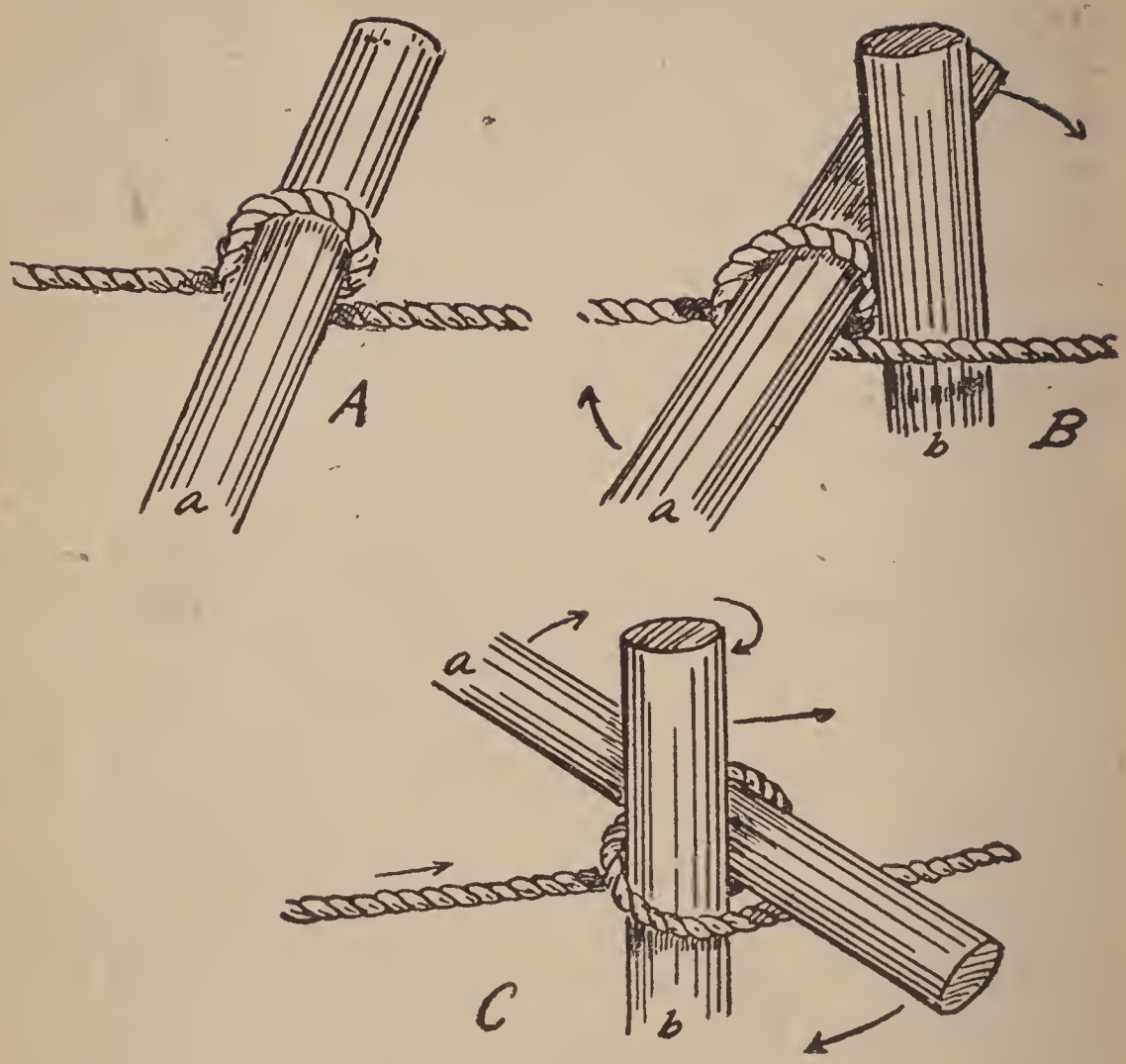


Fig. 30

FIG. 30—Spanish windlass.

as in *Fig. 30, B,* and swing the longer piece around the shorter one, as at *Fig 30, C.*

Continue to turn the long lever around and around the shorter bar, and the car will move slowly and steadily forward. As you turn the lever, a companion must hold the short piece of wood in order to keep it at right angles to the rope, as otherwise it will kick up or swing at an angle and allow the rope to slip off. I have mentioned six feet as the length of the lever, but this is the

extreme, and as a rule a three or four-foot lever will be long enough for all ordinary purposes.

If you are traveling through a country where there is little or no timber, carry a couple of lengths of iron or steel pipe, one to fit within the other. These can be used as a lever and fulcrum for the Spanish windlass. Another method is to carry a tackle block, but this takes up considerable space and it is seldom needed.

GETTING HOME WITHOUT A TIRE

Of all troubles on the road the commonest are tire troubles. Of course every sane motorist carries an extra tire or two and extra tubes, but sometimes one puncture follows another and the motorist finds himself miles from a garage with a flat tire and no extras. If the bad tire is old and comparatively worthless, the car may be driven slowly for many miles with it flat; but this destroys the tire and is likely to injure the rim, to say nothing of the jar and strain on the car.

By winding rope, rags, vines, or twisted straw around the rim and tire a great deal of the strain and jar will be overcome. A still better method is to remove the tire and lash tightly twisted bunches of hay or straw to the rim in place of the tire. This will act like a solid tire and will protect the rim, and it is possible to drive safely over fairly rough roads for many miles in this way. As the lashings wear or cut through, you must stop and replace them, and of course you must drive slowly. A stout rope wound about the rim and lashed with wire, rope, or cord will serve even better. Another excellent

method, where you have a worthless or comparatively worthless shoe, is to stuff it full of straw, hay, moss, grass, or leaves, and then place it on the rim. This will be far better than driving on a flat tire, and a casing treated in this way is often unharmed after being driven for many miles; but whatever method you use, be sure to drive carefully, keep the weight of your load on the opposite side from the crippled wheel, and take your time.

These are but a few hints, a few suggestions, and if you use common sense, ingenuity, and patience you can get out of almost any motor difficulty that arises. The best method of all is *not* to get into trouble; and the only way to accomplish this is to understand your car from end to end, care for it properly, keep everything tuned up and in the pink of condition, look it over before starting and when coming in from a run, making sure that everything is in perfect shape. Remember that it is far easier to make adjustments and repairs in your garage than on a country road, and *always* bear in mind that an ounce of prevention is worth many tons of cure.

COMMON MOTOR TROUBLES, THEIR CAUSES, AND REMEDIES

Trouble: Back explosions; motor kicks back; pounding; clanking noises; loud explosions in muffler.

Cause: Spark too far advanced; motor overheated by lack of oil or water; too much oil or gasoline; carbon in cylinders; thin fin or piece of metal in cylinders; spark-plug points too thin, dirty, or badly adjusted; short circuit in ignition; valves out of time; fan stuck, belt broken or too loose.

Remedy: Retard spark; examine oil and water systems; clean out carbon; try new plugs; go over wiring; test valve adjustments; tighten fan belt.

Trouble: Bad smells from exhaust.

Remedy: See Overheating, Loss of Power, Preignition, and Lubrication.

Battery Troubles: Sluggish action; misfires; preignition; engine starts hard; engine runs well on level or at low speed, but stops or hisses on high or on hills or rough roads.

Cause: Old or exhausted battery; broken or corroded terminals; wires or connections loose; dead cells; short circuits; battery frozen; electrolyte low or exhausted; spark plugs loose, broken, or badly adjusted. If equipped with vibrator or coil, parts may be worn, pitted, or stuck; weak spring on breaker or brushes worn, glazed or loose; breaker badly adjusted; spark retarded too far.

Remedy: Test battery; overhaul all wires and connec-

tions; try new plugs; adjust and clean breaker, vibrator, or distributor; replace brushes; try advancing spark.

Trouble: Bearings squeak or pound, jar, rattle, or seize; engine runs sluggishly; fails to turn over with starter.

Cause: Bearings too tight, too loose, cracked, worn, dirty, or poorly lubricated; crank shaft, piston pins, connecting rods out of line or bent; bearings cut or scored; dirt in oil; motor overheated.

Remedy: Drain off old oil and replace with new; lubricate thoroughly; tighten or adjust bearings; overhaul shaft and bearings; examine cooling system; sometimes due to leaky piston rings; see if crank case is hot.

Trouble: Black smoke from exhaust.
Cause: Too much gasoline.

Trouble: Blue smoke from exhaust.
Cause: Too much oil.

Trouble: Blowbacks; explosive or popping noises at carburetor; flames at carburetor; pound, especially when climbing hills; knock in motor; loss of power; misses at some speeds, not at others; hard to start; blue smoke; pounds with advanced spark.

Cause: Worn or dirty inlet valves; valves badly adjusted; valve stems stuck; valve springs weak; too much air or too little gasoline; preignition; valves out of time; weak spring in air valve of carburetor; carburetor clogged, leaky, dirty, or partly filled with water; too little fuel in tank; leaks in fuel pipes; leak in tank of vacuum or pressure feed; dirt or water in gasoline; clogged strainer in fuel line; float in carburetor stuck, leaky, or

bent; poor adjustment of breaker or distributor; carbon lodged under intake valve.

Remedy: Adjust and regrind valves; try new valve springs; test for valve timing; adjust and clean carburetor; clean and adjust breaker or distributor; clean all fuel pipes and strainers; examine float of carburetor; try more pressure in fuel tank; try new grade of gasoline.

Trouble: Buzzing in coil box or bright sparks at vibrator points; buzzes weakly or irregularly; buzzes when switch is off or timer points not in contact.

Cause: Vibrator points worn, pitted, or loose; dirt on vibrator; coil wet; wrong adjustment; weak batteries; short circuit; coil burned out; timer or breaker badly adjusted, wet, dirty, dry, or badly worn; loose wires; partly broken wires; strand of wire grounding.

Remedy: Clean, file, and adjust vibrator points; test coil and batteries; try a new coil; overhaul wiring; clean and oil and adjust timer or breaker.

Trouble: Circulation poor; motor heats; radiator boils or steams; motor knocks; motor runs after ignition is shut off.

Cause: Air in water pipes; pump broken or stuck; leak in pipes, pump, or radiator; lack of water; frozen pipes, pump, or radiator; inside of hose connections rotten and loose, or hose collapsed, too small, or kinked.

Remedy: Repair all leaks in water system; force water through pipes by hand; replace old hose with new; examine radiator and fill with water; repack pump and examine it; clean out radiator.

Trouble: Clutch grips, grinds, jerks, takes hold suddenly, and is hard to release.

Cause: If disk clutch: dry, dirty, wet, or disk broken; spring adjustment too tight.

If leather-faced cone clutch: dry, glazed, wet, burned, cracked, or worn out; spring adjusted too tightly.

Remedy: Clean and lubricate according to the directions of maker of car; if trouble still continues, overhaul clutch.

Clean with gasoline, and oil well with neat's-foot oil; if leather is black, cracked, or worn out, replace with new leather; loosen spring adjustment.

Trouble: Clutch slips; does not hold full load; motor races when under load; releases too easily.

Cause: Clutch spring too loose; clutch (leather) oily or greasy; leather glazed or hard; some foreign matter or dirt in clutch, preventing even contact.

Remedy: Clean and lubricate as above; tighten spring; try new leather.

Trouble: Compression poor; motor has little power; slows down on hills; crank case heats up; oil in crank case smokes; motor turns easily by hand; hissing sounds when turned over; hard to start; misfires; overheats; requires rich mixture; oil leaks around valves; oil leaks around spark plugs; soft soot in cylinders and on plugs.

Cause: Valves worn, dirty, stuck, badly adjusted, or springs too weak; cams worn loose or broken; cam shaft bent, loose, or broken; cam gears loose or broken; cracks in cylinder; spark plugs or valve caps not tight; broken porcelains on plugs; priming or relief cocks loose or bad;

scored cylinders; piston rings worn, stuck, broken, or joints in line; oil too light; cracked piston.

Remedy: Examine all joints, plugs, and gaskets; try new plugs and cocks; put in new gaskets; try new piston rings; clean, regrind, and adjust valves; try new valve springs; examine cams, cam shaft, and gears; examine piston and cylinders for cracks and scores; try heavier oil.

Trouble: Compression too great; hard to turn motor over; will run idle, but not under load; turns first one way and then the other; pounds; will stop suddenly when ignition switched off; engine heats and clanks.

Cause: Not really a compression trouble; piston stuck or dry; lack of oil; piston rings cracked, broken, or out of grooves; piston pin or crank bearings too tight, dry, broken, worn, or out of line; bent shaft or connecting rod; broken valve stem or cam; valves stuck; trouble in universal joint, propeller shaft, differential, axle bearings, brakes, or elsewhere; carbon in cylinder above piston; too much friction somewhere.

Remedy: Test motor, detached from drive mechanism; if all right, the trouble is not in motor. Clean and lubricate pistons and cylinders; adjust all valves and bearings; loosen up each bearing in turn to test motor; overhaul motor.

Trouble: Connecting rods knock; clanking or light pounding noises, especially when idling; sudden stoppage; vibration from motor.

Cause: Preignition; carbon in cylinders; poor water or oil circulation; motor badly timed; wires led to wrong cylinders; spark too far advanced; too little gasoline; worn, cracked, or loose bearings; water in cylinders or

base of motor; loose set screw or fastener in piston pin; something loose or broken; motor base supports cracked, broken, or bolts loose; connecting rod bent or out of line.

Remedy: Retard spark; try more fuel; clean crank case and use new oil; look over water system; examine plugs for signs of water; scrape out carbon; examine bearings, crank shaft, base, pistons, cylinders, and connecting rods.

Trouble: Failure to start; starter will not start motor; can't start motor by hand; motor turns, but won't start: will race, but will not run slowly.

Cause: Batteries weak, old, exhausted, or frozen; broken, loose, dirty, or poor connections; short circuit; broken wires; starter short-circuited; motor cold; carburetor adjustment poor.

Remedy: See Battery Trouble, et cetera. Let motor run fast until warmed up, or warm it artificially; try hot water in radiator; readjust carburetor.

Trouble: Flame at intake manifold.

Cause: See Back Explosions and Blowback.

Trouble: Flame at exhaust manifold.

Cause: Valves out of time, stuck, dirty, or broken; ignition badly timed.

Remedy: Overhaul valves and ignition.

Trouble: Gears roar, clash, grate, grind, slip, jerk, or fail.

Cause: Worn or loose gears; broken or stripped gears; lack of grease, or grease too thick or too thin; loose bolt, screw, or nut in gear box; cracked or broken gear case; bent or broken shift rods or dogs; loose bearing

or key; dirt or water in gears; failure of clutch to release.

Remedy: Clean and grease gears; examine gear case for cracks; take out and overhaul gears; see that clutch releases.

Trouble: Generator fails; does not charge battery; will not register on meter.

Cause: Broken, loose, or dirty connections; short circuits; worn, glazed, or dirty brushes; armature troubles.

Remedy: Overhaul wires and connections; clean or replace brushes; then, if no better, call in an expert electrician.

Trouble: Ignition troubles; motor runs unevenly; sluggish action; starts hard; will fire priming charge and will not run; back explosions; muffler explosions; pounds.

Cause: About ninety per cent of motor troubles are due to ignition; in case of any trouble of a minor sort, first overhaul and examine the ignition system; short circuits may be easily located by running motor in a dark place and watching for sparks or flashes of light.

Trouble: Knocks or pounds.

Cause: See Circulation, Back Explosions, Connecting Rods knock, et cetera.

Trouble: Loss of power; sluggish or poor operation of motor; will not pull well on hills; black, white, or blue smoke from exhaust; starts easily, but does not run well.

Cause: Usually poor ignition or carburetor adjustment; too much air or too little gasoline causes back-

firing and pounding, as well as missing; too much fuel or too little air causes black smoke, bad smells, overheating, pounding, and missing; too much oil causes blue smoke; a leak in cylinder walls causes white vapor from exhaust; failure to run after starting shows too rich a mixture, or stoppage of fuel supply; if motor runs well at some speeds and not at others, the mixture is wrong; if it backfires, it is too weak; if it chokes, it is too rich.

Remedy: Look over the ignition system; try new carburetor adjustment; clean fuel pipes and carburetor; make carburetor adjustments when under load, not when running idle.

Trouble: Lubrication troubles; overheating; water boils; pounds; clanking noises; misfires; sluggish action; bad odors; blue smoke; squeaks.

Cause: See under these various headings.

Trouble: Misfires; motor runs unevenly and lacks power; base or muffler explosions; hard to start; knocks or pounds.

Cause: See Ignition and under other headings.

Trouble: Muffler troubles; explosions in muffler; noisy exhaust; rattles; hissing sounds.

Cause: Unburned gases entering muffler and exploding by heat or by following charge; muffler choked or too rich mixture; valve troubles; muffler loose, broken, or exhaust connections loose; cut-out out of order.

Remedy: Examine valves, muffler connections, and ignition; clean muffler.

Trouble: Noises and rattles around motor or car.

Cause: Loose nuts, bolts, or small parts, or slightly loose bearings; badly adjusted valve tappets; loose or cracked mudguards; loose lamp connections; loose brake rod; loose bonnet; loose wind-shield parts; loose license pad or bracket; loose muffler supports; loose exhaust connections; loose or bent fan; in fact, any part which is loose will cause a rattle when car is running on rough roads or motor is running fast; often very difficult to locate.

Remedy: Go over car and motor bit by bit and tighten all loose parts; run motor rapidly while idle and try to locate rattle by sound.

Trouble: Overheating.

Cause: See Circulation, Lubrication, Compression, et cetera.

Trouble: Piston troubles; pounds; motor stops suddenly; hard to turn over; piston binds, seizes, or squeaks.

Cause: Poor lubrication; overheating; poor water circulation; piston rings broken or stuck; cylinder scored; piston pin loose or binding on cylinder walls; carbon on piston or cylinder walls; rust or grit in cylinder; water in cylinder; connecting rod or bearings bent, out of line, or dry; carbon or gummy oil in piston-ring grooves.

Remedy: Clean piston and cylinder with kerosene and oil thoroughly; examine rings, bearings, et cetera, and clean well; look for scored cylinders; clean out carbon; if cylinders are scored, have them reground and new pistons and rings fitted.

Trouble: Popping noises in carburetor.

Cause: See Back Explosions, Blowbacks, et cetera.

Trouble: Pounds or knocks.

Cause: See Cylinders, Pistons, Preignition, Connecting Rods, Overheating, Back Explosions, Bearings, Compression, Ignition, Lubrication, et cetera.

Trouble: Shocks from motor or wires or switch.

Cause: Short circuit somewhere.

Remedy: See Ignition and Short Circuits.

Trouble: Short circuits; misfires; shocks from wires, switch, motor, et cetera; sparks at timer, switch, distributor, breaker, or elsewhere; intermittent running; motor stops suddenly; motor won't start.

Cause: Wires grounded; wires wet, loose, broken, or dirty; poor, loose, or corroded connections; batteries or wires in contact; wires led wrongly; breaker contacts do not separate; spark-plug points touching; water on plugs; broken porcelains on plugs; some object across wires; two wires under one staple; worn or broken insulation.

Remedy: Go over each wire and connection, each plug, and, in fact, entire ignition system, until trouble is located.

Trouble: Sparks or light flashes anywhere.

Cause: See Short Circuits, Ignition, et cetera.

Trouble: Spark-plug troubles; short circuits; misfires; lack of power; leakage of compression; irregular running; hard to start.

Cause: Unsuitable, dirty, broken, or poor plugs; plugs too short or too long; wet plugs; badly adjusted plug points; cracked, loose, or broken porcelains; terminal

broken, loose, or corroded; carbon or soot in plug; no gasket under plug; rust or oil between plug and cylinder walls; too much oil.

Remedy: Examine and clean plugs; use new make of plug; clean threads on plugs and cylinder; clean and tighten connections; adjust plug points to about 1-32 to 1-64 inch apart; if plugs show wet oil, feed less oil; always have new plugs to replace old ones in case of trouble.

Trouble: Valve troubles; slow or sluggish action; loss of compression; misfires; loss of power; noisy exhaust; blowbacks; light knocking.

Cause: Sooty or gummy oil on valve stems; valves or stems stuck; spindles or stems bent, pitted, or rough; pitted, worn, dirty, or scored valves or seats; weak valve springs; hole for cotter or pin in valve stem worn oblong; wrong or poor adjustment of tappets, valve stems, rocker arms, et cetera; cams worn, loose, or broken; valve gears worn, loose, or broken, or out of time.

Remedy: Clean valve stems, and, if bent or scored, replace with new; regrind valves; use new springs; see that all lost motion is taken up; adjust so there is about 1-64 inch between tappets and stems; test for proper timing.

Trouble: Water troubles; water in the fuel tank, in pipes, carburetor, or cylinder; loud explosions; steam from exhaust; irregular operation; hard starting; back-firing; popping; water on plugs; rust in cylinder.

Cause: Water will condense in tank or carburetor and will gradually accumulate; leakage around petcocks or

plugs; water in oil; leaky joints or gaskets; cracked cylinder walls; some cock left open in damp weather; porous metal in cylinders.

Remedy: Be sure there is strainer in fuel pipe; strain fuel through chamois; protect tank, et cetera, from rain; drain carburetor and bottom of tank; test all joints; test cylinders for cracks; use new gaskets; drain off oil from base and use new oil.

HANDICAPS MYSTERIOUS

By ROLAND ASHFORD PHILLIPS

(Reprinted from TOP-NOTCH MAGAZINE)

CHAPTER I.

UNPLEASANT DEVELOPMENTS.

Hooded and goggled, lying almost horizontally, with the big, tape-wrapped steering wheel just under his chin, and his steady, watchful eyes focused through the circular wind shield, Bobby Larkin drove his bullet-shaped, battleship-gray racing car down the gleaming white beach.

But for Bobby Larkin and his very able mechanician, James Dandy—affectionately called Jim Dandy—the beach and its beauties held little of interest save as a roadbed for the rubber-shod wheels of their entry, the *Baby Bullet.*

Behind them, like a vicious pursuing bulldog, trailed a low-built, roaring, black car—the *Night Bird;* still back of that thundered a third machine: a freak model of scarred yellow better known among the entries as the *Canary,* and occupied by a single passenger. The three trial-heat contestants shot down the bench, mufflers open, and leaving behind them a trail of smoke.

Jim Dandy, the mechanician, huddled low on the running board of the *Baby Bullet,* kept his goggle-masked eyes fastened attentively upon the many dials below the wind shield, reading in the trembling needles the pulse of the onrushing speeder.

Larkin's sinewy fingers, glued to the steering wheel, scarcely appeared to move; yet it was something of a

task to keep the hurtling car in a straight course at a ninety-mile clip. His eyes, too, shifted from dial to dial as he gradually and guardedly urged the roaring steel mechanism below him to a greater pace. The miles whirled dizzily under the thick-shod wheels.

The yellow car and the black one hung on tenaciously, neither giving a yard, yet neither succeeding in closing in on the open space between themselves and their pace-maker. A broad and satisfied grin overspread Larkin's sun-tanned countenance, and a cheery light glowed in the depths of his squinted eyes. The same expression of contentment was soon apparent on Jim Dandy's freckled face. The handlers of the *Baby Bullet* were well satisfied with their entry's performance.

Five minutes later, however, that satisfied expression suddenly changed to one of decided bewilderment and concern. Both men sensed the unexplainable yet perceptible slowing down of their speed. The wavering needle of the speedometer confirmed their suspicions by dropping from ninety and falling steadily to eighty. It was as if the car were traveling through deep, clinging sands. The engine ran thickly.

Jim Dandy put his lips to Larkin's ear and shouted: "Something—binding! Must be—brakes!"

Larkin shook his head. The brakes were free. Had they been acting queerly he could have detected it at once by the feel of the pedal under his right foot. No, they were all right. It was the engine itself that was wrong.

Jim Dandy looked around. In spite of the fact that the *Baby Bullet* was losing ground, the *Night Bird* had made no perceptible gain. The surprised mechanician shouted that knowledge into his driver's ear.

"Something wrong with the *Night Bird!*" he cried. The information served to increase Larkin's wonderment and dismay.

The next time Jim Dandy looked back he was given a greater shock. The battle-scarred yellow car—the *Canary*—was creeping up steadily. And, even as the mechanician watched, the *Canary* nosed ahead of the

Night Bird and began to annihilate the distance between itself and the *Baby Bullet.*

That news, instantly communicated to Larkin, brought a hard look into his troubled eyes and an unpleasant word tumbling from his lips. He experimented with his spark, made other minor adjustments, and ended up by giving his engine every bit of surplus power in reserve; but of no avail. The laboring pistons would not respond. The dial registered seventy-five—no more—and the car was tuned up to the limit.

There was no use in asking about the *Canary,* for Larkin saw the yellow car tearing up nearer and nearer. Finally it was on even terms with the *Baby Bullet*—then passed it. By that time, to put an end to the agony, the beach narrowed. Daytona was in sight, and the trial heat was finished.

Several miles off shore, a trim, white yacht, with the name of *Silver Heels* painted upon its overhanging stern, plowed gracefully through the water. A man on the bridge—a thickset, smooth-faced individual in white flannels and gold-crested duck cap—lowered his binoculars, which had focused on the racing cars beachward, and addressed the man at the wheel.

"The *Canary* passed 'em both," he announced, and grinned significantly. "Looks like we're in for a good, old-fashioned clean-up, Guthrie. I told you as much, didn't I?"

When the yacht hove to, at last, Burbridge and Guthrie went ashore and sauntered off to the big hotel, where a bottle of Scotch, safely corralled away, awaited them.

CHAPTER II.

A GROWING SUSPICION.

Meanwhile, the *Baby Bullet* rumbled into the garage, and the two unsmiling occupants climbed out.

"Guess we'll have to overhaul the *Bullet* again," remarked Jim Dandy, standing off and surveying the car

with resentment. "I'll be blamed if I know what's got into her. She never balked before."

Larkin removed his driving togs, hung them in a locker, and came back to where the doleful mechanician stood. "Maybe we won't have to overhaul the car, J. D.," he remarked, at length. "Let's go over and see what the crew of the *Night Bird* are doing."

"What's the use of that?"

"I was just thinking," Larkin replied, "that the *Night Bird's* troubles might be our own. Seems odd to me that both cars should misbehave at exactly the same time. I'm going over to their place and see the *Night Bird.*"

When, a few minutes later, he entered the garage that harbored the *Night Bird,* Larkin found, as he expected, that both driver and mechanician were hard at work on the car's engine.

Murdock, driver of the entry, was the favorite in the coming race. He was not a particularly friendly sort of competitor, as Larkin had discovered on previous meetings, and was inclined to resent any and all queries regarding himself and his car.

However, when Murdock looked around to see Larkin in the doorway, he voiced the very question that was upon Larkin's tongue: "You had some trouble just now, didn't you?" It was more of a demand than a query.

"Yes. Engine seemed to balk all at once. My mechanician is tinkering with it now. I came over to learn whether or not you'd located your trouble."

"There doesn't seem to be any trouble," said Murdock. "The engine runs perfectly in here."

"Didn't it seem strange to you that our cars misbehaved at precisely the same moment?" Larkin queried.

"Can't say that it did," returned Murdock. "Why?"

"Oh, nothing much. I just wondered, that's all. Well, I'll go over the course with you in the morning. We'll see if our experience is duplicated. If it is, we'll have something to worry us."

The *Canary,* it might well be mentioned, was the last car to be entered in the race. It had been out on the beach but twice previous to its appearance on this occa-

sion, and neither time had it developed any extraordinary show of speed nor given a demonstration worthy of notice. Its driver—the mechanician took no part in the trials—was a slim, yellow-haired youth, who kept pretty much to himself. On the entry register he was down as Morris Turner, San Francisco. Larkin had seen him on several occasions in the lobby of the principal hotel, in company with two elderly men who had arrived in town the week before in the yacht *Silver Heels.* The harbor master had registered the owner and captain of the smart little vessel as Hamilton Burbridge, home port, New York. The yacht itself displayed the pennant of the Hudson River Club.

Whether by coincidence or otherwise, when Larkin strolled back to his garage he collided with the two yachtsmen and the driver of the *Canary.* Larkin nodded, and would have passed on without more ado, but one of the men stopped him.

"Hello, Mr. Larkin!" he cried pleasantly. "What's the hurry? We are all in the game together, and might as well be sociable. Haven't had a chance to introduce myself before. My name's Burbridge. That's my yacht in the basin. You're driving the *Baby Bullet,* aren't you?"

"Yes, I am," Larkin replied, mentally sizing up his questioner and wondering what had prompted the unexpected display of geniality on the part of the yacht owner.

"Of course, of course," Burbridge took up, all smiles. "Meet my friend Guthrie. Guess you know Turner, don't you? He's another friend of mine, and I'm here to see him win the big race."

Turner continued to survey Larkin through half-closed eyes. "Had a little trouble this morning, didn't you?" he asked.

Larkin nodded. "A little. Brakes binding, I guess. Nothing to worry about, however."

The men from the yacht exchanged glances, and on Burbridge's lips there broke a wide smile. "You've got a good entry there in the *Baby Bullet,*" he admitted; "but

the *Canary* is the bird I'm backing—backing strong. I don't do things by halves. When I do any betting at all I go the limit. You got any loose change that disputes my saying the *Canary* will pull down the purse?"

Larkin shook his head. "My bank roll is pretty flat. I'm out of the betting."

The men parted company. Larkin turned into the garage to find Jim Dandy preparing to get busy with the engine. "Haven't done any tinkering yet, have you?" he inquired.

"Going to it right now," declared the mechanician grimly.

"Is the tank filled?"

"Yes."

"All right. We'll postpone the tinkering. Jump in and we'll go out for a trial."

Jim Dandy, surprised, opened his mouth to object; but he read something in his driver's fixed countenance that instantly waylaid the protest, and, without a word, he dropped the tools he carried and obeyed orders.

A few minutes later the *Bullet* was scooting over the white beach like a hound on the scent of a rabbit. Larkin coaxed the engine into high speed and watched the dial creep up swiftly through the eighty-mile figures into the nineties and finally gain the century mark. That pace was maintained for ten minutes. The engine was running like a watch, with never a miss or a shudder. Jim Dandy's eyes were sparkling, and he looked up at Larkin with a grin that bespoke volumes.

Larkin promptly throttled down, swung the car around, and started back to Daytona. The previous performance was duplicated.

"There's nothing wrong with this baby," Jim Dandy announced gleefully, as the car rolled into the garage. "Not a thing. What do you suppose got into her this morning?"

"That's a problem we'll have to solve before the race," answered Larkin. "I'll tell you to-morrow, after we've had another set-to with the *Canary*. Meanwhile there's nothing to do but wait."

"No fair keeping secrets, Bobby. You ought to tell me——"

Jim Dandy broke off abruptly as a tall, stalwart chap appeared suddenly in the door of the garage. Larkin looked up as the shadow fell across the floor; then he uttered an exclamation:

"Holy mackerel! If it isn't Sam Randolph! Where in blazes did you drop from?" Larkin rushed forward to wring the other's outstretched hand.

"Hello, Bobby!" Randolph greeted. "Surprised, eh? I figured you'd be. I got in from the West coast this morning, knew you were in town, and thought I'd call around and strike you for a job. I haven't been able to hook up with anything worth while since I left California. However, I have hopes."

"Well, I'm tickled to see you just the same, even if I haven't a job to offer you," Larkin said. "Randolph, meet Jim Dandy. He's my chief assistant at present—and I wouldn't change him even for you, Sam."

The men shook hands. "Tough luck for me," Randolph said, grinning. "But keep me in mind, will you, Bobby? You know what I can do."

"I certainly shall. An M. E. like you shouldn't be looking for a place." Larkin surveyed his friend narrowly; then he put a hand into his pocket. Randolph, quick to understand, shook his head.

"I'm not that far gone—yet," he protested, coloring. "But it's a comfort to know where to turn if I get that way. Hang on to your coin, Bobby. I'll give you the sign—when a sign's needed."

"Be sure to remember that, Sam," Larkin said gravely; then, in a lighter tone, he continued: "I'm off for a dip in the surf. Better come along. We've a lot of conversation to exchange."

The two men strolled away, leaving Jim Dandy in charge of the garage.

CHAPTER III.

SOME INSIDE INFORMATION.

Early the next morning the *Bullet* was snorting merrily on the beach, when the *Canary* hove into view, with its yellow-haired driver at the wheel. The *Night Bird* and two other cars took part in the skirmish; and, after jockeying for position, the five machines started up the speedway at a lively pace.

Larkin edged his car up gradually. Murdock's entry and the *Canary* were running on even terms at a sixty-mile clip. At the eighty-mile pace the *Night Bird* and the *Bullet* were running fender to fender, the *Canary* falling back. When ninety miles was gained, the positions of the cars were about the same. Then, without warning, the strange phenomenon of the day before was repeated.

With clouded eyes and set lips, Larkin throttled down the *Bullet* and followed the other cars into the shell road that led toward the garage. Jim Dandy, slumped back in his seat, looked as glum as a critic at a dreary premier.

"I'll be hanged!" he broke forth, at length, prefacing his remark with a couple of expressive and explosive imprecations. "Of all the confounded queer actions! It's uncanny, that's what it is. The *Canary* seems to be a hoodoo for us, Bobby. No getting away from that. When she's in the running, we're out of it."

"I'm going to have a look at that bird," Larkin remarked quietly. "And right now. I've got a fool idea in my head—came to me all at once. I'm curious to know how near right I am."

Having decided upon a course of action, Larkin lost no time in putting it into execution. As he walked briskly along the street toward the garage where the *Canary* was quartered, his mind was revolving swiftly.

He betrayed no unwonted interest, however, when, a few minutes later, he stopped before the open door of the garage. Turner was not in sight. A mechanician

was engaged in changing one of the tires, and whistling as he worked. Larkin nodded to him and strolled into the shed.

The hood of the big car was off, disclosing the powerful engine. Larkin, surveying it with keen and critical eyes, made no attempt to disguise the sudden interest that engulfed him. The mechanician, looking up and apparently quick to read the other's mind, stopped whistling and spoke. "Bet you never set eyes on a prettier engine, did you?" he asked, rather boastfully.

Larkin ran his fingers over some of the exposed parts of the shining mechanism and shook his head. "Can't say that I have," he replied meditatively. "At a glance I'd say the engine was cast from aluminum."

The other chuckled. "You're nearly right. Aluminum is the principal ingredient. It's the lightest and most durable alloy that can be made."

Larkin, keenly interested, would have been glad to make a more thorough examination of the engine; but, as he did not want to arouse suspicion, either by actions or queries, he refrained. After a few complimentary remarks that seemed to please the mechanician, Larkin strolled out of the garage and passed up the street, his mind in a turmoil.

Larkin headed unerringly for the big hotel, and walked through the lobby into the lavishly appointed grillroom. Burbridge, sitting at one of the many tables, hailed the newcomer the moment the driver of the *Bullet* appeared at the door. "Just in time, Larkin," he greeted, in a loud voice. "Join the happy family. What'll you have?"

Larkin took the chair that was drawn out for him, nodded to Guthrie, who surveyed him with none too pleasant eyes, and was introduced to the third member of the trio—a Mr. Carey, the chief engineer of the *Silver Heels*.

Larkin accepted a cigar in lieu of the proffered liquid refreshment, and took the opportunity, while the orders were being given, to study his table companions. He found little to invite confidence in the general appearance of any one of the trio—Burbridge least of all. The lat-

ter personage would have fulfilled admirably the most exacting demands of a stage manager who sought to find a type to portray, without the aid of make-up, the rôle of a shrewd, smooth-tongued, resourceful "con" man.

On the other hand, Guthrie was a morose, taciturn individual, who seemed to hold a perpetual grudge and suspicion against everybody—a man who could neither trust nor be trusted. Of the trio, Carey seemed to be the most prepossessing. He was a thin-faced, blue-eyed Irishman.

As was to be expected, once the orders were served and the conversation floodgates were opened, the subject of discussion was directed upon the one big topic of the hour—the coming motor race. Burbridge began to wax eloquent and boastful.

"Placed a thousand on the *Canary* this morning," he declared jubilantly. "Murdock's entry seems to be the favorite, but at the prevailing odds the yellow bird looks like easy money to me. Wish I would get ten thousand more down before the battle."

"Must be playing an inside tip," hazarded Larkin, and smiled as he spoke.

Burbridge winked at Guthrie, who had taken no part in the conversation. "Maybe I am. Who knows?"

"Looks dubious for me," said Larkin, still smiling.

"Well, you didn't expect to pull down the first money, did you?" Burbridge demanded brusquely.

"I wouldn't have entered the race otherwise," the driver of the *Bullet* replied.

Burbridge laughed. "I admire your grit, young man. But I'll tell you here and now you'll be blamed lucky to finish third."

Larkin did not seem visibly perturbed by the prophecy. "We'll see," he returned. "By the way, Burbridge, where will you be during the race—in the stands, at Sea Breeze?"

"I had intended to be there," the yacht owner said. "In fact, I'd reserved a box; but I've doped out a better idea. I'm going aboard the *Silver Heels*, stand a couple of miles off shore and midway of the course, and

view the whole affair from start to finish through my glasses."

"You won't do much yachting if you don't get me a helper," Carey put in quickly. "I can't handle the boat alone—and goodness knows you or Guthrie won't be of any assistance. Give me a man who is capable of looking after the engines while I'm on deck, attending to my other duties, and you'll play safe."

"Huh," growled Burbridge, "always wanting to increase my overhead charges, aren't you, Carey? Yachts are blamed expensive toys, I've discovered," he added, addressing Larkin.

"You wouldn't need another man if I could stay with my engines below deck—where I belong," Carey shot back, and accompanied the remark with a meaning look, that his employer apparently understood.

"All right, all right," Burbridge hastened to announce. "You'll get your man, Carey. But I'm hanged if I know how or where. I've inquired all around. Good mechanicians don't grow on trees in this country, and the time's too short to send North for one."

At this turn in the conversation Larkin could scarcely conceal his delight; but he sat there apparently indifferent, as if the subject were of no interest to him; and presently Burbridge turned the conversation back into its former channel. For an hour or more the men chatted, then Larkin excused himself and left the hotel.

He would be unable to do more than perfect the plan of action destined to bring about the downfall of Burbridge and his accomplices. He must leave it to his friend Randolph, who, if things ran according to the plan that had occurred to him at the hotel, would be the instrument of the rogues' defeat.

CHAPTER IV.

THE LURE OF ADVENTURE.

In the meantime, Larkin hurried back to the garage, where he found Jim Dandy puttering about the racing machine. "Where did Randolph say he was staying?" Larkin asked.

"If I recollect, he didn't say," the other replied; then, after giving his driver a steady glance, he added: "What's the trouble? You seem a bit excited, Bobby. Found out anything?"

"Enough," said Larkin. "I've landed a job for Randolph. Let's scout around and try to locate the duffer."

After the mechanician had donned presentable clothes, the two men sallied forth in quest of the missing friend. Half an hour's search through the main part of the town was rewarded by coming upon Randolph holding sway over a pool table and surrounded by a crowd of admiring spectators.

Larkin permitted the man to finish the game; then he dragged him bodily away, heedless of his attempts at explanation. "See here, Bobby," he spluttered, "I'm trying to make my room rent, and you——"

"Never mind that, Sam. I've got a job for you. Come along to my domicile, and listen to the tale I'm about to unfold. You've never heard its equal."

Safely established in the apartment shared by Larkin and his mechanician, Randolph drew a relieved breath. "Go ahead—shoot. I'm listening."

Larkin began his tale abruptly and without superfluous introductions. "I think I've unearthed one of the most amazing attempts at swindling that was ever pulled off on land or sea. Burbridge seems to be the ringleader. He has entered the *Canary,* with Turner driving, and backed the entry to win—backed it to the extent of at least five thousand. Now, I may be mistaken, but I'll gamble right now that Burbridge and his pals are out-

and-out crooks, old-time professionals. They're of the breed that play sure things, and go in for a big killing."

Randolph frowned. "Tell me," he began, with a sudden interest, "is the fellow you call Burbridge the chap in yachting togs? A sleek-faced individual, with a grouchy-looking pal in tow?"

"The same."

Randolph leaned back in his chair and laughed. "Well, what do you know about that? You've hit the bull's-eye, Bobby. Burbridge's changed his name since I saw him last, but he's a con man, all right enough, and so is his side partner. The chap you call Guthrie has done time, and Burbridge is a king-pin performer in his line—operating anything from the gold-brick game to booming presumed fruit land in California. I had my first squint at the pair this morning, and wondered what had lured them here. Now I begin to see. Proceed, Bobby."

"Where did you make their acquaintance?" Larkin inquired.

"I didn't, thank you. But I've been a part of an audience while they were doing their act. That was in California. They had a fake land scheme blooming. Were selling off sections of the desert at fifty dollars an acre to trusting widows and gullible strangers—representing the land to be suitable for citrus groves. An aunt of mine invested ten thousand, and lost it, of course. The money would have come to me at her death. They got away with their game, and vamosed overnight."

"Well, Sam," Larkin said, "you're elected to queer their game this time. You won't get back the ten thousand, but you'll get a powerful lot of satisfaction. You're going to accept a position on the yacht *Silver Heels,* as an assistant to the chief engineer."

Larkin proceeded to relate in detail the results of the trial heats upon the speedway, the queer behavior of the *Bullet* during the spins, and the persistent winning of the *Canary.* To that he added what he had learned regarding the *Canary's* engine, of the heavy wagers Burbridge had placed upon the entry, and followed it up by giving his listeners a logical solution of the mystery, as

well as a possible method of frustrating the well-laid plans of the conspirators. When he had finished, the two men seated opposite him were openly astounded.

"Great Scott!" Jim Dandy managed to articulate at length. "Do you figure that's the answer?"

"I do," Larkin replied confidently. "Now, what about accepting the position on the yacht, Sam?"

"Lead me to it!" cried Randolph.

The next moment the door closed behind him and he was off at a brisk trot for the pier and the yacht that was anchored alongside it.

CHAPTER V.

WHEN THE FLAG DROPPED.

For the ensuing three days that preceded the race, Larkin heard nothing from Randolph personally; but he did learn, from a chance meeting with Burbridge, that the applicant for berth of assistant engineer had passed inspection with Carey and had been engaged.

During the time of Randolph's absence the racing cars were put through their usual daily spins. On the two occasions when the *Canary* was entered in the trial heats, it won; but Larkin was not disturbed by the performances. What the other drivers thought was, of course, not publicly known. However, the odds of the *Canary* dropped a trifle on the strength of its consistent showing and because of the heavy wagers placed upon it by Burbridge; and by the time the final sheet was posted, the yellow car was rated in a higher class. Yet the bookmakers were not banking too much on the trial performances; they believed that Murdock had not seen fit to let out his entry, and would not do so until the proper moment.

With the exception of Murdock's entry, the other cars were classed as dark horses, with no past performances upon which to base any sort of dependable prediction. The *Bullet* was an unknown quantity. Lar-

kin had entered the car in two previous races, but without demonstrating any unusual achievements, finishing third in both cases. Therefore it was not to be wondered at that the bookmakers considered the *Bullet* as a vague possibility.

While Larkin and his mechanician were giving all their attention to the *Bullet,* and priming it for the final test, Randolph, as assistant engineer of the *Silver Heels,* was gaining the respect of Carey and the confidence of his employer. Guthrie, however, did not warm up perceptibly to the new member of the crew, and took occasion on several instances to voice a warning to Burbridge.

Randolph soon got the lay of the ship, and proceeded to make deliberate and guarded observations. However, he was tactful enough not to ask foolish questions or to appear to be too interested in the equipment of the yacht. He demonstrated that he knew as much regarding marine engines, especially those of the heavy, oil-burning type, as did Carey.

The *Silver Heels* was a trim little eighty-foot craft, with three fair-sized cabins on deck. Among Randolph's early surprises was the fact that, so far as he could see, the yacht was minus a wireless equipment. At least there were no aërials visible. He was assured later, by Carey, that the vessel did not possess that luxury.

While Randolph was allowed a certain amount of liberty on board, he was never left in sole charge of the craft. Despite that, however, he managed to inspect two of the three deck cabins; the third one, situated amidships, was kept securely locked and shuttered.

So matters stood on the morning of the race.

There were eight entries in the Daytona Sweepstakes, and all of them were out on the course at dawn for a final tuning up and inspection. Numbers had been allotted to the entries and painted in glaring colors on the back of each car. Larkin drew No. 5, the *Night Bird* drew No. 3, and the *Canary* No. 7. Beside the official starter and a judge and a few disinterested spectators from the neighborhood, there was a scant crowd to see the get-

away. All those interested had departed an hour before to the stands built on the beach at the finish line, thirty-five miles distant.

After an unnecessary amount of jockeying and ear-splitting explosions, the eight cars lined up, and eight expectant drivers and their mechanicians primed themselves for the grueling test. Off to one side the starter held aloft a flag. Sixteen pairs of eyes were riveted upon that piece of fluttering cloth. The white beach was glaring in the hot February sun, but a cool breeze came in from the Atlantic, rippling the flag in the official's hand and stirring the tufted plumes of the stately gray-trunked palms.

The flag dropped amid a roar of unmuffled exhaust, for every one of the eight powerful engines were turning at high speed. Eight drivers stiffened in their seats, tightened their fingers upon their steering wheels, and threw in their clutches.

In a twinkling Daytona was left behind in a cloud of black, gaseous smoke as the cars shot up the beach like a flock of death-dealing, fire-belching monsters.

The *Bullet* was between two unknown entries, No. 6 and No. 4. The *Canary*, labeled with a 7, was farther up the beach, while the *Night Bird*, wearing a 3, was nearest the water. For the first five miles there seemed to be no perceptible difference in the speed of the contestants; then the *Night Bird* began to draw ahead slowly, with the *Bullet* and the *Canary* a length behind. The other five cars were bunched in the rear and displaying very little form. Already they seemed to be outdistanced; yet they kept on with a dogged persistence, hoping for a break.

At the fifteen-mile post, the *Bullet* and the *Night Bird* were side by side, while the *Canary* hung on twenty yards behind. The dial below Larkin's steering wheel registered ninety miles—passed that figure, and kept creeping up. And Larkin still had power in reserve. Jim Dandy, huddled low behind the wind shield, grinned. Larkin felt confident and jubilant. Apparently Randolph, on board the yacht, had succeeded in his mission.

Another five miles—then the thing that Larkin feared came to pass. His engine began to slow down, scarcely perceptibly at first, then more and more evident. The needle of the speedometer fell back steadily, and just as steadily the *Canary* began to edge ahead.

Doubt and apprehension began to arise in Larkin's heart. Something had befallen Randolph; that much was certain.

Fifteen minutes before the race was due to start, the *Silver Heels* put away from her pier and stood out to sea. Guthrie was at the wheel. Burbridge, binoculars glued to his eyes, was on the bridge. Carey, having given instructions to his assistant, hurried up on deck.

A sudden shout from Burbridge warned Randolph that the flag had dropped and the battle begun. He called the oiler, put the man in charge of the engine, then bounded up the ladder to the deck. He edged along the rail on the starboard side of the yacht until he had gained a position opposite the door of the cabin, amidships.

Burbridge was far too interested in developments ashore to divide his attention with what went on beside him. Carey was not to be seen, and Guthrie was forward, in the pilot house, with the two deck hands. Thus Randolph figured he had a clear stage to begin his drama. His hand went out to the knob of the door. It turned easily in his fingers, and he felt the door give readily to his pressure.

As the door opened cautiously, Randolph had a flash of Carey and of the inner fittings of the cabin. He broke into a hard laugh and started across the cabin floor.

At the same instant a step sounded behind him. He whirled part way to see Guthrie bearing down upon him. Then something struck him over the head and he toppled headlong.

CHAPTER VI.

PRETTY LIVELY WORK.

Randolph lay where he had fallen, face downward. His head throbbed cruelly, but fortunately he was still in command of his faculties. He had been worsted in the first encounter, but the fight had more rounds to go, and he intended to be in strong at the finish.

He heard Burbridge's voice outside the cabin door: "The *Canary* is forging ahead! Another fifteen miles and the race is won."

Randolph opened his eyes guardedly. What he saw pleased him. Assured of his advantage, he flung out his arms, gripped Guthrie by the ankles, and, half rising, tumbled the surprised man to the floor. The instant that Guthrie fell, Randolph bounded to his feet and rushed forward. He was just in time to face Burbridge, who, startled by the noise, had dashed into the cabin.

With a cry of delight, Randolph pounced upon Burbridge, picked him up bodily, and flung him in Carey's direction. The engineer had bolted from his chair at the moment of Guthrie's disaster; but his movement came an instant too late. Burbridge crashed into him, and, with waving arms and legs, the two men, swept down like pins in a bowling alley, brought up against the wall of the cabin amid a splintering of wood and broken glass.

"Help, help!" babbled the excited yacht owner, lifting his voice to attract the attention of the other members of the crew. But there was no response to his distress signal. The oiler was below deck, beside the noisy engine, and could not know of his employer's peril. One of the deck hands was at the wheel, and could not desert it. The other man sped along the deck, took one glance through the open door of the cabin, and wisely sped away again. He had shipped as a deck hand—not a scrapper.

Randolph broke into a merry laugh. "Say, this is too easy!"

"What do you propose to do now?" inquired Burbridge sullenly.

Randolph pondered. "Hanged if I know exactly. I wasn't given instructions for your disposal. However," he added briskly, "I'll take the yacht and its precious cargo to the dock nearest the finish line and turn the command over to Larkin. He'll deliver the sentence."

CHAPTER VII.

IN THE THIRTY-FIFTH MILE.

With the *Canary* fifty yards ahead of him, Larkin suddenly felt the laboring engine of the *Bullet* respond as quickly as if he had thrown off the brakes. He knew what that meant, and breathed an exclamation of thanks to Randolph. Jim Dandy instantly realized the situation, too, and let out a yell that was wrenched from his lips by the wind. Up, up, crept the needle of the speedometer. The finish line was in sight, with its stands and waving spectators.

The *Night Bird* bounded forward with the *Bullet,* as if both cars, after topping a hill, were rushing down into a valley. The *Canary* fell back. For a second the three contenders were nose to nose; then the *Night Bird* and the *Bullet* pulled away from the yellow car.

Larkin gave his engine the last ounce of power. He was swaying in his seat. His fingers were numb from their mighty grip upon the tremulous steering wheel. The field had been left hopelessly behind, and there was only the *Night Bird* to dispute the *Bullet's* victory. But the black car was a real contender, and Murdock himself a veteran driver. To win out over the favorite would be an achievement worthy of praise.

The stands were looming faintly in the distance, like a picture of an onrushing train thrown upon a screen. In less than five minutes the contest would be over. The

thought of all that those fleeing minutes might embrace nerved Larkin for a supreme effort.

Still side by side, the two cars hurtled forward, spitting fire like dragons, neither giving nor gaining a yard. The roar of the exhaust was deafening. It smothered the cries of the spectators who dotted the side lines of the course.

Larkin cautiously shifted his eyes for a fraction of a second and fancied he could detect the slightest falling back of the *Night Bird.* His heart bounded exultantly. It was a question of endurance now, of machine against machine.

Once more Larkin dared to shift his gaze to the right. A thrill shot through every fiber of his tense body. The *Bullet* had gained a yard—more than that. Its long, slender body was away beyond the sloping fenders of the *Night Bird.*

Now the stands were upon him. He saw dimly the spectators; their waving arms and hats and the flags that rippled in the wind. But he heard nothing save the roar of exhaust. He hugged his wheel, his eyes fastened straight ahead of him. The broad band that marked the finish line swept up and under him in the winking of an eye. Then subconsciously he released the clutch and guardedly applied the brakes.

The next thing he knew Jim Dandy was thumping him furiously on the back and shouting like a madman: "We've won, Bobby! Won by six yards! Whoop-ee!"

A few minutes later the *Bullet,* snorting proudly, returned past the stands, to be acclaimed by the excited crowds who rushed out upon the beach to greet the winner. Larkin waved his hand. The *Night Bird* came up. Murdock jumped out and ran over to pay his respects to the man who had finished ahead. There was no trace of envy in his congratulations and handclasp. The other cars rumbled up to meet with good-natured gibes from the spectators. The *Canary* alone was conspicuous by its absence. The yellow car, with Turner at the wheel, had finished third. After it had passed the stands, it turned off to the left and disappeared inland.

Looking oceanward after the demonstration had subsided, Larkin beheld the *Silver Heels* putting in toward the long pier. He whispered a word to Jim Dandy, flung off his headgear and goggles, and, making his way through the excited crowd that surrounded the cars, departed on a run. There was still another act to the real-life drama, and Larkin intended to be a principal in its unfolding.

On the way to the pier he fell in with two other men, also running. One of them he recognized as the local chief of police; the other was a stranger. The men looked oddly at Larkin, but offered no comment. And the winner of the big contest was too much engaged with his own thoughts to question the purpose of his newly found companions.

Suddenly a revolver shot echoed. The running men halted abruptly, and looked toward the yacht. The craft had veered off its course, and apparently did not intend to make a landing. Another shot sounded. Then the figure of a man could be seen running along the deck of the yacht. He poised for a second at the rail, and dived headlong into the sea.

An exclamation fell from Larkin's lips. "Get a boat —quick! That chap can't swim all the way in to the pier." It flashed on him suddenly that the man in the water was Randolph.

Without further explanations, the three men jumped into a small motor dory, cast off the ropes, and started out toward the swimming figure. The *Silver Heels* had swung about and was heading oceanward at a lively clip.

Larkin, standing forward in the dory, gave a shout as he recognized the swimmer. "All right, are you, Sam?" he called anxiously.

"All right, Bobby," Randolph answered.

A moment later Randolph was picked up and hauled over the side of the boat. "How about the race?" he spluttered first of all, ignoring the presence of the two other men in the boat.

"The *Bullet* won by six yards," Larkin answered.

"Bully!" Randolph gave a cheer. "We should worry now. Tell you what, Bobby, we——"

The stranger who had accompanied the chief of police stepped forward, pulled out a pair of handcuffs, and snapped them upon Randolph's wrists.

"You're under arrest, young fellow," he announced gruffly. "And I warn you not to make trouble. I'm from New York police headquarters, and I won't stand for any monkey business."

CHAPTER VIII.

CLEARING SKIES.

Randolph, still dripping from his plunge, looked from the steel bands upon his wrists into the face of the detective. "Say, what's the joke?" he inquired, puzzled.

"No joke so far as I can see," returned the officer. "I've been on your trail for a week. You and your pals have come to the jumping-off place."

"Just a minute, Mr. Detective," Larkin put in quickly, realizing the mistake that had been made. "This man is a friend of mine. I'll explain the——"

"No explanations necessary," the detective interrupted curtly. "I know my business. And if you start interfering, I'll arrest you, too. This chap and his pals stole the yacht, out there." The detective nodded toward the disappearing *Silver Heels*.

The dory made a landing. The officers piled their grumbling captive into a waiting machine and whirled off toward Daytona. Larkin, with a few words of explanation to the astonished Jim Dandy, got into the *Bullet* and shot away in pursuit of the other car.

Three-quarters of an hour later, Larkin was at police headquarters, in presence of the detective, the chief, and Randolph. "Just give me five minutes and I'll satisfy you that everything is O. K.," he began, as the detective growled something about not being interested in any fool explanations. "I asked Randolph, the man you've arrested, to get a job on board the yacht to frustrate the

plans of Burbridge and Guthrie—the pair you want to apprehend. If it hadn't been for Randolph, gentlemen, the *Canary* would have won the race to-day, and Burbridge's crowd would have departed with several thousand dollars that——"

"What's the race got to do with this affair?" the chief demanded.

"It has everything to do with it," Larkin replied. "Now pay close attention to what I have to say. During the trial heats on the beach, previous to the race, the engine of my car and many of the others behaved in a most singular manner. I couldn't figure out where the trouble lay at first. Each time the *Canary* entered in the sprints, it won easily, and the engines of the other cars misbehaved. Yet at other times, when the *Canary* was not present, we had no trouble at all. Also, when our trouble was apparent, and the *Canary* was running against us, the yacht *Silver Heels* was standing off shore. It was that very situation that gave me my first clew. I demonstrated on several occasions, and to my satisfaction, that either the yacht or the *Canary*—or both—was producing a powerful influence upon my engine. Later, I found an opportunity to look at the *Canary's* engine. I discovered that it was cast from a certain new alloy, the principal ingredient being aluminum. That fact pretty nearly convinced me that my suspicions were correct."

"What suspicions?" asked the detective, obviously interested in spite of himself.

"That the *Silver Heels,* standing offshore during the trial heats, was exerting a powerful magnetic influence, by means of an ingenious wireless apparatus, upon the engines of all the entries save that of the *Canary*. The electrical waves, directed through the air, magnetized our engines, interfering with their working and cut down the horse power, owing to the fact that they were built of steel and iron. But the same waves had no perceptible influence upon the engine of the *Canary* because, as I stated before, it was cast from a neuter compound—aluminum, as you know, being one of the poorest metal

conductors of electrical energy. Burbridge and his crowd, certain they could make the *Canary* a winner, played it to the limit. That knowledge was still another item that convinced me that I was working on the right lead."

"Great Scott!" ejaculated the astonished chief, impressed by the story he heard. "Why didn't you come to me? I would have arrested the crowd at once, and the trouble——"

"But I lacked absolute proof," Larkin broke in; "and without it we could have done nothing. I doubt if you would have arrested the men merely on my suspicion."

"Maybe not," the chief answered. "The chances are I would have laughed at your charges. Fact is, I didn't know the yacht was stolen property until the detective from New York tipped me off about an hour before the race. And, before we could take action, the boat had put off to sea. We figured on making the capture after the race."

Larkin nodded. "Then it seems that I have acted wisely. I had to nab the conspirators at work. Also, I had to put their apparatus out of commission and permit the race to be run on the level—which it was. I was far more interested in making the race a legitimate one than in trying to apprehend the crooks. Randolph, the man you've arrested by mistake, is an old friend of mine, an electrical and mechanical engineer. He applied to me for a position as mechanician. I had none. But luckily there was an opening for him on the yacht, and he secured it. He set off the fireworks, and the honor belongs to him."

"Nothing of the kind," Randolph protested hurriedly. "I did nothing but follow instructions. Any dub could have done the same."

Larkin smiled. "We won't discuss that point now," he said. "I've told all I know. You'll have to continue the story, Sam."

"There's nothing of interest to tell," Randolph began modestly. "If it had ended as well as it began, I might have been satisfied. But I messed things at the finish."

He went on reluctantly to tell of his adventures aboard the yacht, treating the affair as of little consequence, and dismissing the dangers that had confronted him with a brief word or two.

"I was stumped at first when it looked as if the yacht was not equipped with a wireless apparatus, but I came to the conclusion it must be concealed in the one cabin that the flimflam artists wouldn't permit me to enter. It was there, all right enough; and when I broke in, a few minutes after the race had started, I saw Carey, the engineer, hard at work with the sending mechanism.

"We had a little scrap, nothing much to brag about," Randolph went on, "because the crooks were too yellow to fight after the first round. I managed to smash the wireless apparatus the first thing, and I was satisfied then to stand by and give the bunch the merry ha, ha! I did want to get a squint at the mechanism and see how it was constructed, but I couldn't get a chance; and I guess the thing was too badly smashed at that to get much information from.

"I planned to bring the yacht and her crew to the pier," Randolph continued, "and ordered the helmsman to direct her course for the landing. Everything was going smoothly, and I got a bit careless. One of the deck hands got hold of a gun somehow, and took a pot shot at me just about the time the pier was within hail. I couldn't locate the fellow, so I felt duty bound to save my own hide by diving overboard. You saw the rest. Here I am, not much the worse for wear—and the crooks are safe at sea on their stolen property."

"We'll get the crooks," the chief spoke up briskly. "They're out at sea now, but they can't remain long. I'll wire the police at every port on the coast, and if we don't get word of their capture within twenty-four hours, I'll be surprised."

The detective nodded. "Sure thing," he said. "I'm not worrying now. I'll have the trio safe in New York before the week's ended."

"And how about yours truly?" queried Randolph.

The detective grinned. "Oh, you're all right. I'm

due for a great big apology. Your description doesn't fit that of any one of the crowd I'm after. I've been a little too hasty in my zeal. When I saw you diving off the yacht I figured you were one of the party."

"I was one at the party," said Randolph, with a chuckle. "I reckon you might call me the unwelcome guest. But I had more fun than my hosts."

"Whom did the boat belong to, and how was it stolen?" asked Larkin, eager to hear the details that had brought the detective on so long a journey.

"Burbridge and Guthrie, with the help of the engineer, Carey, who double-crossed his original employer, made a bold coup and got away with the yacht from its anchorage in Brooklyn," the detective said. "The owner put the case in my hands, and I've been on the jump for the last month. The thieves changed the name of the boat and repainted her superstructure. But I had a tip that she'd come South, and made up my mind that Burbridge would be a spectator at the Daytona races. And my tip was a good one."

"Then Carey fell in with this pair of crooks," Randolph supplied, "a deal was framed up, and the trio took possession of the yacht and its very admirable equipment and sailed for the sunny vineyards of Florida, where the pickings were ripe. Oh, the whole affair's simple enough to understand now."

"Just as simple as adding two and two," said the detective. He produced a handful of cigars and passed them around. "The smokes are on me, gentlemen," he confessed. "I've been the nanny. But sometimes the best of us get excited and make mistakes.

"And now," he continued, bestowing an admiring glance upon Larkin, "permit me to offer my tardy congratulations on your victory—your double victory, I should say. You've pulled down a fat purse for yourself and put me in the way of bagging a couple of slippery crooks and a no-good engineer. That's glory enough for one day, isn't it?"

THE END.

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