MOTOR TRUCK DESIGN AND CONSTRUCTION

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PREFACE

This volume has been written to fill a pressing want; to give a practical discussion of the gasoline propelled commercial car of the present type, and to present this subject in the plainest possible manner by the use of numerous illustrations. In other words, this work is compiled for the engineer, who, when he desires information on current practice, may quickly obtain the same without a general study. At the same time a general outline of the underlying principles is given for the student, commercial vehicle owner and operator who may desire to familiarize himself with the construction of the various units that make up the complete vehicle.

The author feels confident that he has been successful in the production of a serviceable treatise on the subject of Motor Truck design and construction.

C. T. SCHAEFER.

ANDERSON, IND.,
Sept. 1, 1919.

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CHAPTER I

THE GENERAL LAYOUT OF THE CHASSIS

Any commercial vehicle conforming to the accepted standard of construction may be divided in two parts, the chassis and the body. The chassis or running gear as it is sometimes called, consists of the frame, power plant, springs, axles, wheels, brakes and in fact all units which enter into the propulsion and control of the vehicle.

There are three general types of chassis when classified according to the type of power plant, the gasoline, the steam and the electric. The gasoline propelled vehicle is by far the most popular and will be considered in this work.

The general layout of the chassis covers such points as the location of the driver's seat or cab in relation to the location of the power plant, which controls the distribution of the useful or pay load of the vehicle. This affects the overall length and turning radius of the vehicle.

The principal problem confronting the commercial vehicle designer is how to make use of the overall length of the chassis to the best advantage, considering accessibility and all other factors which enter into this problem.

Most designers have placed the driver's seat back of the motor. This necessitates the making of the total length of the machine somewhat greater than it would be for the same capacity when the driver's seat is placed above the motor. In some cases a compromise is effected between these two by placing the driver's seat and steering to the right or left side of hood which encloses the motor, thus saving about half the space used in the design which has the seat placed in back of the motor.

Advocates of each type have a number of arguments in favor of their design, all of which have merit. The one who places the seat over the motor, claims that by this arrangement, the load is shifted somewhat forward and the center of gravity is brought somewhat nearer the center of the machine. This is claimed to create more even tire wear all around and a reduction of the total overall length of the chassis. The last is an advantage as it permits a shorter wheel base and turning radius.

Those who place the seat back of the motor claim that in the above construction too much weight is placed on the front axle, that the motor is more accessible and that it is placed in a higher position in the frame. The front springs can be made somewhat lighter, since they are not required to carry as large a percentage of the total load. And being lighter, they are less stiff and take the shocks of the road more readily, which tends to increase the life of the motor. These widely varying views of the makers are echoed in many different lengths of commercial vehicles which have been placed on the market.

Probably no single feature of commercial car design merits more attention than does that of arranging the power plant in such a manner as to offer the user motor accessibility in the greatest degree consistent with reasonable compact design. The importance of the first desideratum will be admitted by anyone having experience in the operation of an internal combustion engine. The day is still far distant when a gasoline engine may be locked in a box and with a supply of essence, be expected to mote satisfactorily until like the justly famous Shay, its multitudinous parts give out simultaneously as a result of legitimate wear. The desirability of compact arrangement will be endorsed as a purely academic proposition and will be heartily subscribed to as a thoroughly practical feature by truck operators, who have had to deal with metropolitan street and garage conditions.

As far as the power plant arrangement is concerned American makers have formed themselves into three distinct classes. First, the class comprising those who place accessibility above all other considerations. Second, the class comprising those whose greatest satisfaction arises from the contemplation of a design in which the compact arrangements of parts is accentuated. Third, the class comprising those who have attempted to effect a compromise between the above two types, to secure both accessibility and compactness.

Advantages of Placing Motor Under the Hood.—A layout of the trend of the first class of commercial car design is depicted in

Fig. 1. It will be noted that the motor is carried under a removable hood in front of the driver's seat and control elements, being typical of current passenger car chassis design. The loading platform is divided into approximately equal parts fore and aft of the rear axle. This design permits of easy access to the motor and accessory parts from both sides and top, making it

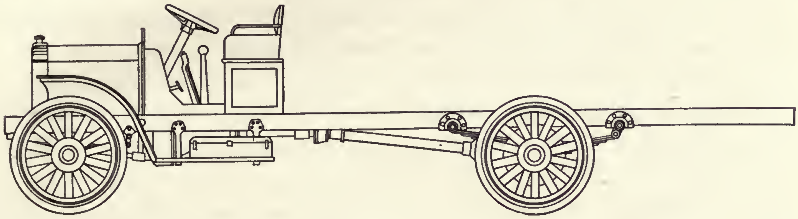

Fig. 1.

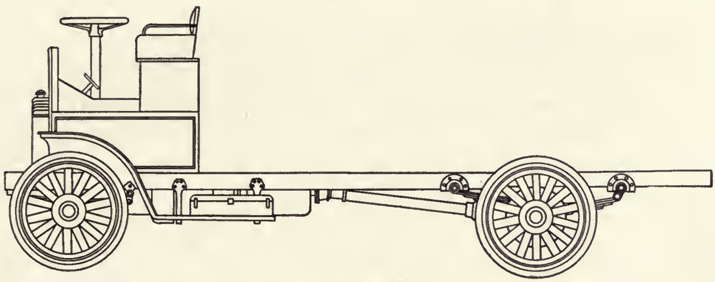

Fig. 2.

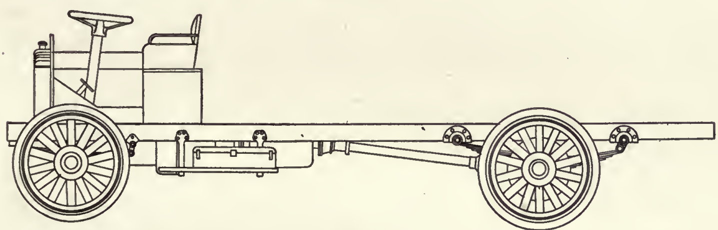

Fig. 3.

Three Prominent Types of Chassis.

equal in point of accessibility to passenger cars. The driver's seat is also accessible while the clutch and change gear can be easily reached through the floor board opening when they form a unit with the motor. The greater percentage of the paying load is concentrated upon the rear or driving wheels, resulting in good traction and easy steering. This construction also results in a pleasing appearance, which is of some advantage in smaller vehicles, which are used to some extent as an advertising feature.

Disadvantages of this Type.—Like all other constructions the above type offers certain disadvantages. The overall length of the vehicle must be greater in order to permit the location of the motor under a removable hood. In many cases this added length does not operate as a decided disadvantage for average application in which the machine must be maneuvered, in narrow thoroughfares, backed up to curbings and garaged in valuable space, every inch of added length makes itself felt in the owner's purse. With the question of load distribution it may be said that careless freight handlers are just as likely to place the light, bulky portion of a miscellaneous load forward of the axle, and to burden the overhang with heavy material, occupying little space, as they are to reverse the loading. Concentration of both driving and load stresses to a maximum degree upon one pair of tires causes loss as far as tire economy is concerned.

Motor Under the Seat Type.—Turning now to the type of construction representative of the second class of design, we find illustrated in Fig. 2, a vehicle in which the driver's seat and controlling elements are superimposed upon the motor space, the load being apportioned fore and aft the rear axle in an approximate ratio of 2 to 1. The result of this load distribution is that it does not permit of a traction ratio so high as does the previously described type, and steering is perhaps less sensitive. But when the high friction coefficient of rubber is considered upon average road surface and the fact that roller bearing steering heads are to be found in most commercial car axles of modern design, then these two conditions become relatively important. In respect to the load distribution, the latter construction possesses advantages over the first type. For a given loading space the construction in Fig. 2 permits of marked compactness in overall length, with the attendant advantage of ease of handling, minimum projection into through fares when backed up to a curve and economy of garage space.

Lack of Accessibility.—These relative advantages are gained at the expense of motor accessibility. Doors or removable panels are usually fitted to allow access to the motor from the side, while floor boards permit limited access from the top. When front fenders are provided the access from the sides is also materially reduced. This notable lack of accessibility arises, first, from the necessity for rigid and fairly bulky superstructure for carrying the driver's seat and second, from the fact that a maze of control levers, brackets and rods are frequently located in the space which should be reserved for access to the motor and its accessories. Many trucks show a marked improvement in this construction, however, at best it leaves much to be desired in the way of accessibility.

Type Three a Combination.—There is still another type, Fig. 3, which has been introduced several years ago, in which an attempt is made to combine the advantages of the first and second types is apparent. This has been accomplished in a measure, by mounting the motor in a more or less accessible position between the two seats. A removable hood is generally fitted, but the net result is almost invariably inferior from a standpoint of accessibility to the construction shown in Fig. 1, although from the same viewpoint it is an improvement over Fig. 2. The advantage of longitudinal compactness is retained, moreover the weight is well distributed between the front and rear axles.

In making the illustrations, the writer has taken pains to have the wheel base (*i. e.*, center of front wheel to center of rear wheel), and the length of the loading in equal proportions in all illustrations so that a good idea can be obtained as to relative overall length and weight distribution.

It can readily be seen that in the point of overall length, the construction which embodies placing the driver's seat over the motor has the advantage of requiring less length than the other two types. While, on the other hand, the question may be asked, are the advantages to be gained by placing the driver's seat over the motor great enough to outweigh those claimed for other constructions?

The general advantage of either construction presents itself when the conditions of operations are considered. The vehicle may be operated in districts when traffic is congested, which would favor class two, while on the other hand accessibility may be the chief point to be considered, which then would favor class one. While certain conditions may suggest the selection of class three. In the smaller vehicles class one is greatly desired owing to its pleasing appearance when fitted with expense bodies.

From the above it can readily be understood that the construction of a vehicle is somewhat depended upon the conditions of operation and nature of the work it has to accomplish.

CHAPTER II

THE MOTOR TRUCK ENGINE—ITS CONSTRUCTION AND LUBRICATION

Two and Four-cycle Multi-cylinder Motors.—This term cycle is defined as the cycle of operations or, in other words, the successive actions of the working fluid of a heat engine upon the piston and of the piston upon the working fluid commencing when a certain relationship between the two exists and ending with the next recurrence of the same relationship; or, in other words, any series of events occurring in succession, which goes to make up a complete operation.

There are four things which must occur in an engine cylinder in succession before it can repeat. As soon as the explosion occurs, the gas must expand, which forces the piston down to the end of its stroke. Upon the completion of this stroke or the next up stroke the spent gases must be gotten rid of by forcing them out of the cylinders; then a fresh charge must be drawn in and compressed before the explosion again takes place.

This series of operations is termed the cycle of operations. There are two types of gasoline motors, one comprising that type which has a power stroke every revolution, which is termed the two-cycle or two-stroke type, and the other which has a power stroke every other revolution, termed the four-cycle or four-stroke type.

The Two-cycle Type.—As mentioned above, the characteristic feature of the two-cycle motor is that there is an explosion every revolution on the down stroke of the piston. Another feature of this type of motor is that the gas must be precompressed, which is generally accomplished by admitting it to the crank case before it reaches the cylinders.

There are two general types of two-cycle motors, known as the two- and three-port types, so called, by the number of ports in the cylinders, which permit gas to enter and to escape after combustion. The three-port type is mostly used in motor truck work, while the two-part type is strictly a low-speed motor and best adapted to marine work, where speed is a minor consideration. In depicting the operations of a two-cylinder motor, the three-port type will be considered, as it would be useless to use considerable space on a subject which is of no interest.

In four-cycle motors the four events mentioned above, *i.e.*, ignition, exhaust, intake and compression, take place between the piston head and the head of the cylinder, but in the two-cycle type the crank case is made air tight and performs part of the work of getting the gas ready to ignite.

The successive operations of the two-cycle motors are as follows: While the piston is traveling upward in the cylinders it creates a partial vacuum in the crank case, and when it reaches a certain point it uncovers the intake port *A* in the walls of the

CYCLE OF OPERATIONS IN A TWO CYCLE MOTOR.

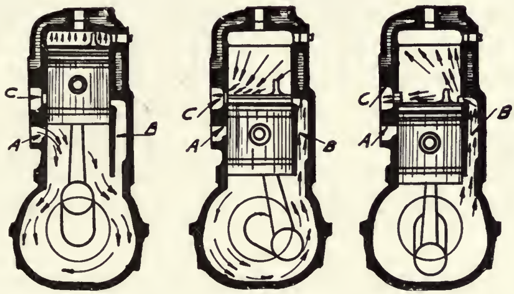

FIG. 4. Crank Case Inlet and Cylinder Compression.

FIG. 5. Expansion and Exhaust.

FIG. 6. Exhaust and Transfer of Gas.

cylinder, through which, by reason of this vacuum, it permits a charge of gas to enter the crank case from the carbureter. This stroke is illustrated in Fig. 4, while Fig. 5 depicts the next down stroke of the piston. During this down stroke, the charge is partly compressed in the crank case. As the piston reaches the bottom of its stroke, it uncovers the port *B* in the cylinder wall, which communicates with the crank case and is called the transfer port, thus permitting the charge in the crank case to enter the cylinder. Shortly after the piston starts on its up stroke it closes this transfer port, and during the remainder of this stroke the charge is compressed within the cylinder and as it reaches the top of its stroke the charge is ignited, expands and forces the piston downward. As the piston reaches the bottom of its stroke the exhaust port *C* is opened, and the spent gases which are still under considerable pressure escape through this port. This exhaust port opens a trifle earlier than the transfer port, permitting considerable of the spent gases to escape before the fresh charge is admitted to the cylinders. This is illustrated in Figs. 5 and 6. It is, of course, impossible to completely scavenge the cylinders and prevent the fresh charge from escaping through the port *C*; however, the piston has a deflector *D* which is intended to deflect the incoming gas upward and reduce the loss to a minimum. This deflector must be placed opposite the exhaust port.

From the above we can readily understand, that when the charge is being compressed in the cylinders on the up stroke of the piston and before ignition takes place, a fresh charge is permitted to enter the crank case and when ignition takes place the gas expands, forcing the piston downward and nearing the bottom of its stroke it uncovers first the exhaust port, permitting a fresh charge to enter the cylinder, after which compression within the cylinder again takes place, thus completing all four operations in one revolution of the crank shaft or two strokes of the piston, crank case intaking and cylinder compression on the up stroke, expansion, exhaust and transfer of charge from crank case on the down stroke.

The Four-cycle Type.—The same operations occur in the four-cycle type of motor; however, they require two complete revolutions of the crank shaft or four piston strokes. This comprises the following operations as mentioned below: (1) Admission of charge to the cylinder, (2) compression of charge within the cylinders, (3) ignition and expansion of charge, (4) exhausting spent gases.

In four-cycle motors the inlet and exhaust of the charge is entirely controlled by valves instead of the piston and ports in the two-cycle motor. During the past few years numerous types of valves have been used, such as the piston type, which may be compared with a small piston opening and closing the ports at the proper time, sliding sleeve, operated on the same principle, and poppet valves which are opened by a cam mechanism. The sleeve and piston valve motors have been experimented with for pleasure car work; however, in commercial cars poppet valve motors have been almost exclusively used in this country, and the writer will confine his discussion to this type of four-cycle motor. As mentioned above, the first stroke of a four-cycle motor is the admission or intake stroke.

The piston travels downward in the cylinder and at some point in the wall of the combustion chamber an inlet valve is located, which at the proper time opens and places the combustion chamber in communication with the carburetor (see Fig. 7). As this valve opens the piston has moved downward a short distance, and a vacuum has been formed with the cylinder which creates a suction and permits the charge to enter. These valves were formerly operated by this vacuum within the cylinder and

CYCLE OF OPERATIONS IN A FOUR CYCLE MOTOR.

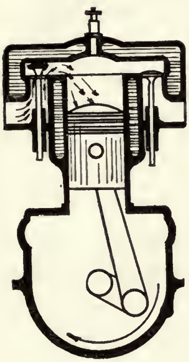

FIG. 7. Intake Stroke.

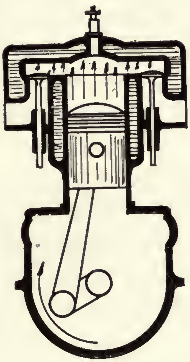

FIG. 8. Compression Stroke.

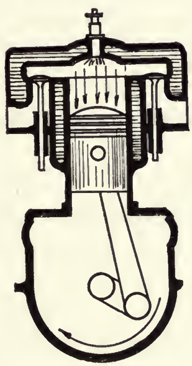

FIG. 9. Power Stroke.

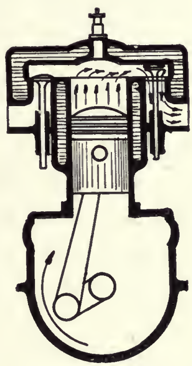

FIG. 10. Exhaust Stroke.

a light spring to close them when suction ceased. This type was known as the automatic intake valve, but was discarded some years ago, as it presented numerous disadvantages. At the present time mechanically operated intake valves are used, which are opened and closed by mechanical connection with the motor crank shaft at the proper time.

This valve remains open until piston has passed the bottom of its stroke, and shortly after the piston has started on its up stroke it closes and remains closed during the completion of this up stroke. During this up stroke the charge is compressed within the combustion chamber (which is sometimes termed the compression space) and prepared for ignition. So far the piston has made two complete strokes, and the crank shaft one complete revolution, while two operations have been completed within the cylinders, this second operation being shown in Fig. 8.

Upon the completion of the compression stroke the gas is ignited by introducing an electrical spark to occur within the combustion chamber. When the charge is ignited the pressure rises to between four or five times what it was previously, causing the gases to expand and thus forcing the piston downward and converting the heat of these gases into useful energy or power. This stroke, known as the power stroke, is illustrated in Fig. 9.

When the piston reaches the bottom of its stroke the exhaust begins to open and the spent gases escape rapidly. This exhaustion of spent gases continues all through the following return stroke of the piston, the valve remaining open until the piston has again moved downward a slight distance and then both valves remain closed for a short period to create the vacuum which causes the suction of gases from the carburetor on the intake stroke, and permitting the motor to again resume its cycle of operations.

The exhaust valves are always operated by mechanical connection with the motor crank shaft, similar to the intake valve; however, timing is different, as they must remain open longer than the intake. In two-cycle motors the exhaust and transfer ports must be placed opposite each other; however, the valves of the four-cycle type of motor may be placed in various positions, as both valves are never open at the same time. Fig. 10 clearly illustrates this point. The exhaust valve is shown and the piston is traveling upward, while when the intake valve is open the piston must travel downward.

In presenting these illustrations the writer has depicted valves on both sides, so as to simplify the illustrations as much as possible. In the various motors the following valve arrangements may be found: The valves may be on opposite sides of the cylinder, which is called the T-head type while in others they are located side by side, and known as the L-head type; they are also located in the cylinder heads, and by combination of one valve in the head and the other in the side; however, the first three are the most popular types.

Advantages and Disadvantages of Both Types of Motors.—In the two-cycle motor we find that both the exhaust and transfer ports are open together for certain periods, and it can readily be understood that since we are performing the four operations in two strokes of the piston, the time required for each operation is limited. It was also stated that the exhaust port opened slightly before the transfer port and that a fresh charge was admitted before the spent gases had entirely escaped. From this we can assume that all the spent gases do not escape and that there is a possibility of part of the fresh charge escaping through the exhaust port, and the fresh charge becoming deluged with the spent gases which do not entirely escape. In comparing the exhaust and intake periods of both types of motors, we find that these periods cover but approximately one-half the time in two-cycle motors than in the four-cycle type. The combination of these operations and the short periods naturally permit of less fuel economy in the two-cycle motor. That considerable fuel is wasted has been proven by exhaust gas analysis on numerous occasions.

In the four-cycle type we get a greater charge in the cylinders due to the longer period, as one complete stroke of the piston is required and this is maintained during the compression stroke as both valves remain closed. This is of great importance in high-speed motors, as even with the long periods intake becomes very short when the higher engine speeds are reached and much less gas enters the cylinders. Even in lower engine speeds it presents advantages. The cylinder also maintains its full volume until after combustion occurs and the exhaust gases are forced out of the cylinder by the return stroke of piston, during which time the intake valve remains closed and no dilution of gases occurs. Of course, some spent gases remain in the cylinders of a four-cycle motor; however, the quantity is much less and does not have much effect on the next fresh charge.

There is also considerable power loss in two-cycle motors, due to leaky pistons, crank case joints and cylinders and bearing journals. This is of considerable importance, as the gas is partly compressed in the crank case and can escape through the exhaust port, should the rings leak or through the various joints, should they not remain air tight.

In four-cycle motors power is lost through leaky pistons, and valves; however, it is not as great and is of little importance as the engine will continue to run and develop a small amount of power. This is not the case with the two-cycle, as in the first place the fresh charge is somewhat limited and, second, it can escape before it reaches the cylinder, sometimes causing complete stoppage of the engine.

Leaky valves can readily be reground at a small cost without dismantling the engine, while to eliminate leaks in the two-cycle means complete dismantling, which is an expensive item, as new bearings must be provided in case they permit gas to escape, it being impossible to adjust them with shims and retain an airtight case. Crank case leaks are also of serious nature, as the motor must be dismantled in order to replace the gaskets at the various joints. Replacing rings is probably of equal expense in both types.

The manufacturing cost is lower in the two-cycle type, while it is also somewhat more simple, due to the absence of the valves and their operating mechanism. As there are fewer parts and the limitations of their proportions also means lower weight per horse power for the two-cycle type, and it is also claimed that they develop somewhat more power and have a better mechanical balance. However, these features are obtained at considerable expense in maintenance and it would seem that the logical commercial car motor is one which provides the lowest maintenance cost in proportion to the work done, which refers to the four-cycle type.

The four-cycle motor also has its disadvantages, being more complicated, more expensive to build and perhaps its weakest point is the valves; however, they are readily accessible, and do not mean much expense in regrinding or replacements. Leaky inlet valves alone permit the diluting of the charge with spent gases and indirectly reduce the power of the motor. The valve operating mechanism of course is a source of complication and expense and would be eliminated if this could be done without too great a sacrifice in other directions.

It is also a well-known fact that carburetion is more difficult in the two-cycle motor, which may be due to the fact that the suction of the carburetor is more rapid and uneven in this type than in the four-cycle type.

Two-cycle motors also require considerably more lubricating oil and can not be lubricated by splash, owing to crank-case compression. Forced lubrication from an outside source must be used. While the two-cycle engine has been built for the past twenty or thirty years, it has not been deemed worthy of the serious attention of many engineers, and it has not yet reached anything near the standardization and perfection of the four-cycle engine.

Multi-cylinder Engines.—For small moderate powers a single-cylinder engine possesses the advantages of the simplest possible construction, inexpensive to manufacture and maintain, and more economical in the use of fuel. Along with its advantages, however, it possesses two inherent defects, particularly from the standpoint of its use in commercial cars, for which reason it is new seldom employed. In discussing the cycle of operations it was stated the power impulses were irregular, due to the fact that a power stroke occurs every other stroke, or every fourth stroke and that the gases which are compressed in the cylinders require a certain portion of power to accomplish.

Therefore, in order to keep the engine running at a fairly uniform speed against a nearly constant resistance it is necessary to employ a heavy fly-wheel in which some of the energy liberated on the power stroke can be stored, to be given out again during the idle strokes.

A single-cylinder motor is sadly lacking in mechanical balance and the vibrations are great. These vibrations are due to the reactions of the explosion and inertia forces. In a single-cylinder motor the entire reciprocating mass (*i.e.*, the piston with its parts, the connecting rod, bearing and crank pin), is in a single unit and the reaction of the inertia force of the parts produces a strong vibrating effect, while in multi-cylinder motors the reciprocating masses can be divided into several units and so arranged as to move in opposite directions, thereby neutralizing the inertia effects.

The two-cylinder motors present some advantages over the single-cylinder type. However, their use is also somewhat limited, and it is only a question of time until all commercial cars will be equipped with four-cylinder motors. The two-cylinder type presents an advantage over the single cylinder in that there are two reciprocating masses, so arranged that one effects the force of the other. However, perfect balance has not been reached and vibrations are still noticeable to a considerable degree.

In the four-cylinder motors now extensively used in commercial cars, the two inside reciprocating masses work together and the two outside work together. However, they are so arranged that the two inner ones always set against the two outer ones. Although they are equal in weight, they operate in opposite directions.

The turning movement of a four-cylinder motor is also much more uniform than that of a one or two-cylinder motor, hence the torque reaction and vibration due to it are much smaller. This four-cylinder type when properly constructed meets the requirements of vibrationless running quite satisfactorily.

Types of Cylinders and their Parts.—From what has been previously said of the piston strokes and crank shaft revolution it can readily be understood that the piston travels up and down within the cylinder, while the crank shaft rotates in its bearings, in order to impart a turning effort to the rear or driving wheels of the vehicle through suitable power transmitting units. This conversion of reciprocating into rotary motion will be depicted below.

Advantages and Disadvantages of Different Types Discussed. —The construction of a gasoline engine is quite simple in its elementary form, being comprised of a cylinder, a piston provided with rings operating within the cylinder, a pair of valves or ports which permit at the proper time the entrance and escape of the gases, a connecting rod which connects the piston with the crank shaft, a case which supports the crank shaft and carries the valve operating mechanism, this valve mechanism being comprised of a shaft with separate or integral cams, suitable shaft bearings and a train of gears driven from the crank shaft; also a set of push rods which act as intermediate members between the valve stems and the cams.

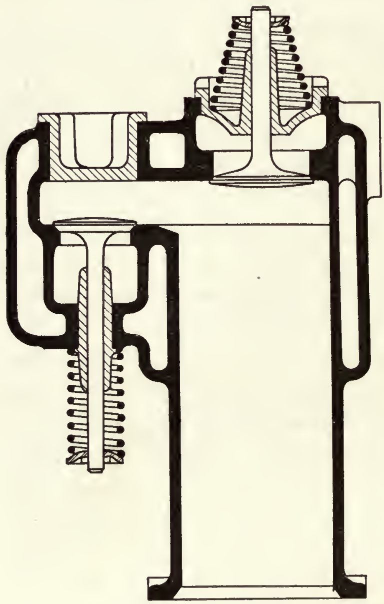

Fig. 11. Section of a Cylinder. A Combination of Valve-in-Head and L-Head Type.

The cylinders are usually castings made from close-grained iron provided with either water jackets for water cooling or fins, sometimes called ribs for air cooling. They are open at one end, while the other end is closed, forming the combustion chamber, in which the valves are located. The walls of this cylinder are made very smooth and are generally brought to a high polish by grinding, so that the piston with its rings can slide freely within the cylinder. This cylinder, with its parts, is bolted to the crank case, which carries the various other parts. Fig. 11 depicts a cylinder in section showing its various parts.

The pistons of gasoline engines are of the trunk type, as illustrated in Fig. 12, being somewhat longer than the diameter of the cylinder. Near the center of the piston bosses are formed, which receive the piston pin or gudion pin as it is sometimes termed. Near the top three or four grooves are turned into the piston which receive the eccentric piston rings, while near the lower end oil grooves are turned for distributing and collecting the surplus lubricating oil on the cylinder walls. These pistons are made a trifle smaller in diameter than the cylinder to permit of the expansion of the metal on the power stroke, while rings, carried on the piston, permit of flexibility, so that the gases cannot escape by the piston.

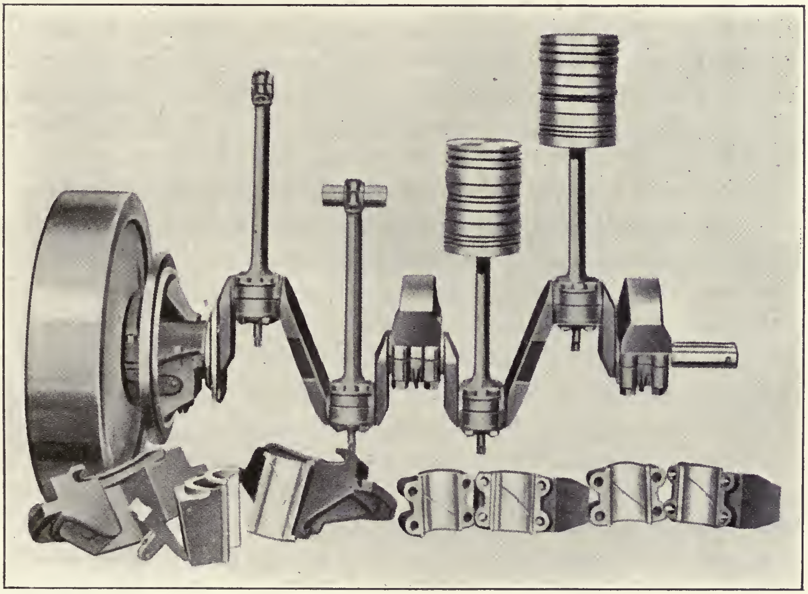

Fig. 12. Connecting Rod, Piston Pin Crank Shaft, Flywheel and Main Bearings of a Four Cylinder Engine.

The crank shaft is a horizontal steel shaft carried in journals, or bearings, inside of the crank case, while offsets corresponding with the number of cylinders are provided. These offsets are termed the crank pins and carry the large end of the connecting rod and its bearings; it is also provided with a taper or flanged end to which the flywheel is attached by means of a key or nut or bolts.

The connecting rod forms an intermediate link between the piston and the crank shaft. It is usually made a drop forging, the small end carrying a bearing for the piston pin, while the large end is divided and carries the crank pin bushing.

It was stated above that the piston travel was a reciprocating motion while the crank shaft revolution was a rotary motion, and that it was necessary to convert this reciprocating motion into rotary motion, for the reason stated above. This conversion of motion is performed by the connecting rod, as it is hinged to both piston and crank shaft and this conversion of motion may be depicted as follows:

When the piston is at its upper point of travel in the cylinder the crank pin is standing vertical above the crank shaft, but as the piston and connecting rod move downward under the influence of the expanding gases within the cylinders, the crank pin is constrained and revolves downwardly, thus turning the crank shaft. The crank pin passes through its horizontal position and as the motion of the piston and connecting rod continues, finally reaches a position vertically below the crank shaft, the piston at this moment being at its lowest point and the crank shaft has been revolved through one-half revolution. As the piston begins to move upward upon its return stroke the crank shaft is again constrained by the connecting rod to revolve and gradually approaches and passes its other horizontal position and finally, when the piston is all the way up, the crank pin has reached its original vertical position again, having turned the crank pin through one complete revolution.

Thus it can readily be understood that the upper end or piston pin end of the connecting rod reciprocates in harmony with the piston, while its lower end or crank pin end rotates in harmony with the crank pin, converting the reciprocating motion of the piston into rotary motion of the crank shaft. It should be remembered that in multi-cylinder engines the explosion force in one cylinder will move the piston downward in the other cylinder which is paired with it and is on the intake stroke. Thus in Fig. 12 the two end crank pins are vertical and while the right hand one is being forced downward it carries the left-hand pin with it. The left-hand cylinder being on the intake stroke, it also forces the two lower crank pins upward, the corresponding cylinder of one of these being on the compression stroke and the other on an exhaust stroke. In this way the right-hand pin is revolved upward when the lower pin on the compression stroke begins to move downward on the next power stroke which, as stated in the previous article, follows compression. This operation is followed by all crank pins on the various power strokes of the pistons.

In the single-cylinder motors this return motion is obtained by the storage of energy in the flywheel on the power stroke, which liberates itself on the idle strokes of the piston. This was discussed under the heading of multi-cylinder engines.

The operation of the parts in two-cycle motors was depicted previously, also the function of the valves in four-cycle motors, the function of the valves being to permit the entrance and escape of the gases from the cylinders at the proper time. These valves are termed poppet valves and consist of a disc of metal with a stem on one side, which closes a circular opening in the combustion chamber, being held against the seat in the wall by a coiled wire spring. The opening and closing of these valves is by a force imparted from the cam shaft, which will be treated later.

Commercial car engines of the poppet-valve type are generally classified by the location of the valves within the cylinder, as this point generally controls the entire construction of the motor, as well as the various factors which enter into its design. The various types of cylinders classified by their valve arrangements are as follows:

T-Head.—A type in which all valves are located in pockets at opposite sides of the cylinders.

L-Head.—A type in which all valves are located side by side in one pocket, on either right or left side of the cylinder.

Valve in Head.—A type in which all valves are located in the cylinder head, placed vertically or at an angle.

There are also several other types which are combinations of those depicted above, having one valve in the head and the other in a pocket at the side, or both valves in a pocket at the side, one being located above the other.

The first and second types, namely the T-head and the L-head, are by far the most popular type used in commercial cars. However, quite a few of the others may also be found. The first three types possess an advantage in that all working parts may be inclosed and thoroughly protected from grit. They also present a neater appearance in that it is a simple matter to keep them clean, as all parts are lubricated internally.

The writer is presenting several illustrations which depict these various types taken from illustrations furnished by the various makers of these engines.

Fig. 13 depicts the conventional type of T-head cylinder in which all the intake valves are located on the right side and all the exhaust valves on the left side, the valves being inserted through openings in the combustion chamber, which are covered by valve port plugs that carry the spark plugs.

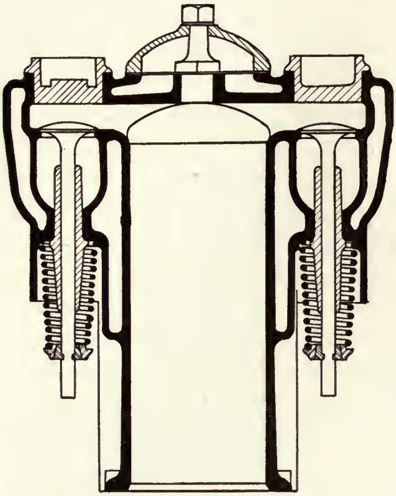

FIG. 13. Sectional View of T-Head Cylinder.

Fig. 14 depicts the conventional type of L-head cylinder in which all intake and exhaust valves are located on the left side, the intake and exhaust valve of each cylinder being located side by side in a pocket. The valves have conical seats, as those depicted in Fig. 13, and are also inserted through openings in the combustion chamber, which are closed by the valve port plugs. The plugs which cover the intake valve openings carry the spark plugs, while the exhaust port plugs carry the relief or priming cups. In this motor the valve springs are of conical shape, the object of this being to obtain a more gradual seating of the valve. The valve stems and operating parts are also enclosed; however, two aluminum plates are used, each covering four valve stems. They are retained by a wing nut and stud, which may be quickly removed.

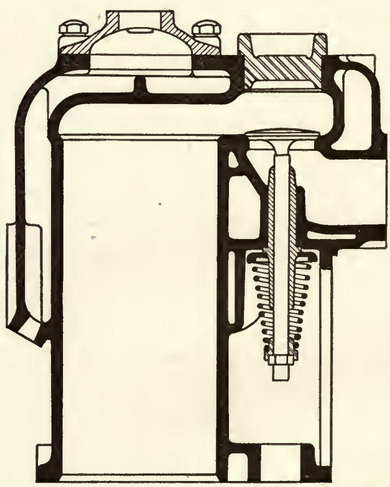

FIG. 14. Sectional View of L-Head Cylinder.

Fig. 15 depicts a valve in the head-type cylinder in which the valves are placed vertical. The valve stems only pass through the cylinder and for this reason the cylinder is divided in two parts at the top of the compression space. Valve guides are used to provide a bearing for the valve stems, and coil wire springs keep the valves closed. This construction presents an advantage in that the entire compression space may be machined to a polished surface, thus reducing the tendency for carbon to collect in the combustion chamber and dividing the cylinder at this point also facilitates the removal of carbon when it does form. If this type of cylinder were cast in one piece it would be necessary to remove it from the engine in order to grind the valves, unless they were mounted in cages which could be removed.

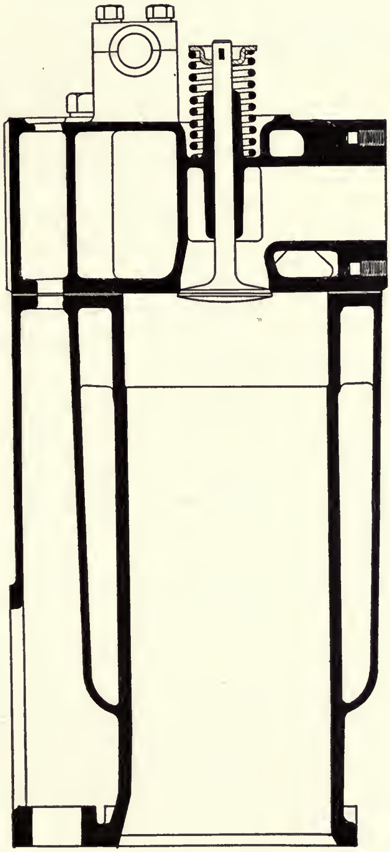

Fig. 15. Sectional view of Valve-in-Head Cylinder.

Fig. 11 depicts one type of the combination of types and is the only arrangement resorted to by American makers, the other type of placing one valve over the other has never been used on commercial car motors to the writer's knowledge, the combination in this type being identical with the construction of the other types from which they were derived, one valve being located in a pocket and operated directly, while the other is located in the head and is carried in a cage in the cylinder head and operated through a rocker arm.

During the past year there has been a tendency to divide L-head cylinders of the motor used in light delivery wagons, so that part of the crank case could be cast integral with the cylinders. This construction, of course, presents advantages in the removal of carbon, valve grinding, finishing of the combustion space, as well as reducing the cost of manufacture. It remains, however, to be seen just what popularity this construction will gain in the heavier types of motors.

There are various ways of grouping cylinders, as they may either be cast single, in pairs or en bloc. Where they are cast single the motor becomes of considerable length and, of course, requires a much longer hood; this additional space when added to the loading compartment would naturally be of considerable advantage. Casting them in pairs shortens the motor somewhat. However, the ideal construction is obtained when the cylinders are cast en bloc, which permits of the shortest possible hood length. It also presents an advantage in the shorter length of the vital parts such as the crank and cam shaft, crank case, etc., as the space wasted can be put to good advantage by the increasing of the main bearings and the shortening of the unsupported parts of these shafts.

This method of cylinder grouping can be applied to any type of motor, or valve arrangement, and is not dependent upon any one construction. En bloc cylinder construction does present a very simple and neat motor, especially when all parts are properly enclosed.

The Valve Operating Mechanism and the Crank Case.—Having described the functions of the valves in their respective cylinders, we can next consider how their operation is accomplished, at the proper time, by mechanical connection with the crankshaft.

Functions of the Cams and Cam Shaft.—This is accomplished by cams which are attached to, or formed integral with, a shaft termed the "camshaft," which in turn is driven through a gear, which meshes with an idler gear, or with the crankshaft gear. When an idler or intermediate gear is used it is so placed that it will mesh with both the crankshaft and camshaft gears. It is only used when the latter gears cannot be meshed directly, due to the difference in centers between cylinders and valves and the two shafts.

The camshaft is so designed that the rise of the cam is brought into operation at the proper time, causing the valve to be raised from its seat and to permit a charge to enter or escape from the cylinder. This cam only causes the valve to raise from its seat; in other words, causes the valve to open, while the valve spring performs the function of closing it and holding it down on its seat until the cam again opens the valve. In the discussion of the two and four-cycle motors it was pointed out that one valve opens during each revolution of the crankshaft, the valves alternating, first one and then the other. From this it can readily be understood that the camshaft must revolve at one-half of the crankshaft speed, thus necessitating a two to one reduction in the timing gears.

In this case we also have to convert a rotary motion into a reciprocating motion. However, as no permanent connection is made with the camshaft, this becomes a simple matter by providing what is termed the pushrod, one end of which communicates with the valve stem and other end rests on the cam. It is provided with a suitable bearing so that its relation with the camshaft can always be maintained.

These pushrods may either have the bearing or guide in the crank case or in the base of the cylinders. When the valve stems are enclosed it is more advantageous to place them in the cylinders, as it somewhat simplifies the machining operations of the case and also the assembling of the motor. These pushrods are always provided with adjusting screws, so that as little lost motion as is practical may be present between the valve stem and the cam. This feature can also be maintained through these screws which are locked in position by lock washers and nuts.

All T-head motors require two camshafts, while the balance of the types illustrated require but one shaft, as all valves can be operated from one side of the motor. Two camshafts could be used in the other types, excepting the L-head, but this of course would add complications in the motor. The train of gears for operating the valve and the accessories is dependent upon the number of shafts and the general distribution of the accessories. They are generally provided with helical teeth and located in a housing at the forward end of the crank case. They must be completely enclosed so that they may be effectively lubricated and protected from dust. This housing is generally built into the case and provided with a cover plate.

The Crank Case.—The crank case, as mentioned in the previous installment, serves as the main structural part of the motor, carrying the cylinders, crankshaft, camshaft and accessories, and is in turn supported in the vehicle frame. It also forms a housing for these important parts, protecting them against dust and mud, and also performs important functions in connection with the lubrication of the motor. The crank case generally forms either a cylindrical or box-shaped housing of sufficient size to enable the crank pins with their respective connecting rods to rotate freely within it and sufficiently long to accommodate all of the cylinders of the motor, which are bolted over the opening in the top of the case.

The general design of this case depends, of course, upon the number of cylinders, the valve location and the size of the crankshaft and its bearings.

There are various methods of mounting the motor in the vehicle frame, each having its advantages and disadvantages. The case is generally provided with four arms, which may either be cast integral or bolted to it, when main frame mounting is resorted to, while for sub-frame mounting they are always cast integral.

Lately there has been quite a tendency toward the use of a three-point support for the motor so as to eliminate stresses in the case, due to frame weaving from road irregularities. This type of motor support may either be incorporated in the motor, by using a separate arm pivoting around the crankshaft center at either the front or rear end, when main frame mounting is resorted to and by incorporating this support at either the front or rear end of the sub-frame when the latter mounting is used.

Crank cases may either be formed in one piece with a separate oil reservoir or in two pieces divided on the horizontal center of the crankshaft. They may either be cast iron or aluminum and in several instances manganese bronze has been used. Aluminum is the most popular, provided with separate steel supporting arms which are bolted to the case, owing to the heavy vibrations due to the solid tires.

Unit Power Plants.—Quite a few of the commercial vehicles use the unit power plant in which the gear box or transmission is bolted directly to a housing cast integral with the case and surrounding the flywheel, or by separate arms which are bolted to the rear motor arms. However this method is very rarely resorted to in the heavier types owing to the large size of the transmission, its weight and the necessity of providing a separate jackshaft for chain driven vehicles.

Like all other units of the commercial car, there are various designs which have been worked out and giving excellent results, and the writer presents illustrations of the types conforming to the general outline of the motors referred to.

The writer will not endeavor to describe the various methods of mounting the engine in the vehicle frame, as this can be done more clearly by devoting a chapter to this feature which will cover all of the present methods pertaining to all units mounted in the frame.

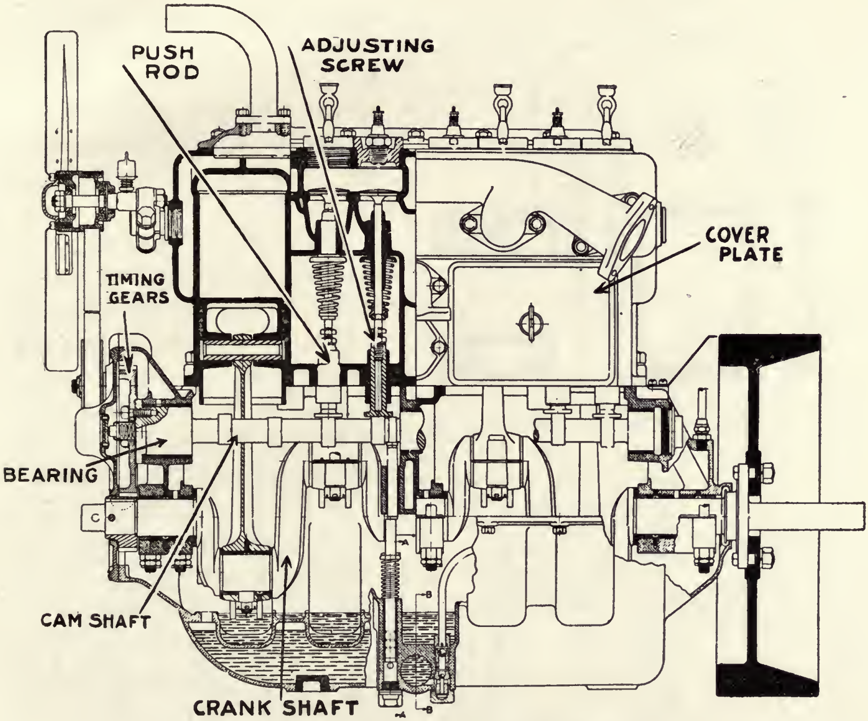

Fig. 16. Showing Valve Mechanism of L-Head Motor.

Fig. 16 shows the valve operating mechanism used on a prominent L-head commercial car motor, illustrating how the valves are located side by side. The European type of valve, with conical seat and the most popular method of enclosing the valves to protect them from dust and foreign matter, are shown. The pushrod guides are pressed into the cylinder and can readily be removed from the bottom of the same. When the cylinder is removed from the crank case the entire valve mechanism, excepting the cams and their shaft, is removed with the cylinder, a noteworthy feature when the overhauling of an engine is considered. The pushrod is of the mushroom type and the outline of the cam is formed of curves, to further assist in obtaining a quieter valve action. The conventional type of pushrod adjustment incorporating a hardened steel screw and lock nut is used. This view also shows the large bearing provided for the cam shaft so that it may be removed through the forward end of the case. Helical teeth are used on the timing gears and the end thrust is taken by a hardened steel pin supported by a spring which transmits this thrust to hardened steel washer on the timing gear housing cover.

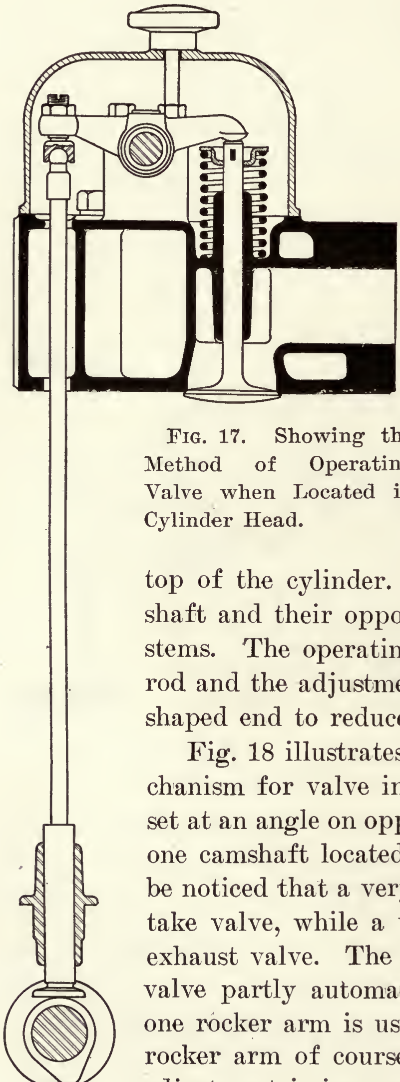

Fig. 17. Showing the Method of Operating Valve when Located in Cylinder Head.

Fig. 17 illustrates the method of operating the valves when they are located side by side in the cylinder head. The pushrods are similar to those previously described above, however, the adjustment is omitted here and incorporated with the rocker arm mounted on top of the cylinder. These rocker arms pivot on a shaft and their opposite ends bear against the valve stems. The operating rod placed between the push-rod and the adjustment in the rocker arm has a ball-shaped end to reduce wear at this point.

Fig. 18 illustrates the overhead type of valve mechanism for valve in the head cylinders with valves set at an angle on opposite sides and operated through one camshaft located on the cylinder heads. It will be noticed that a very light spring is used for the intake valve, while a very stiff spring is used for the exhaust valve. The object being to make the intake valve partly automatic, owing to the fact that but one rocker arm is used to operate both valves. The rocker arm of course replaces the pushrods and the adjustment is incorporated in the ends of the arms. The rocker arm has a roller bearing against the cam, and these two parts are kept in contact by a large spiral spring. The camshaft bearings are divided, but require considerable attention, as a wick feed is resorted to for supplying lubricant. The cam, roller and other parts are exposed so that grit and foreign matter can reach them, and it is a contruction very hard to lubricate due to the intense heat on the cylinder heads.

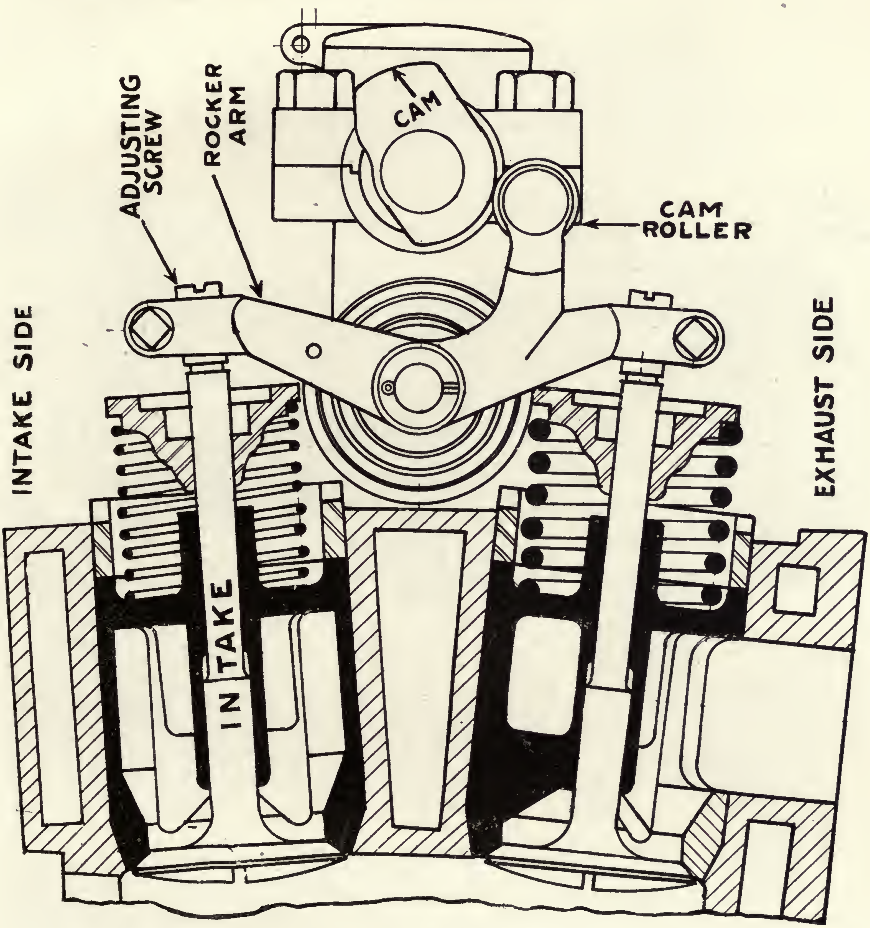

Fig. 18. Overhead Type of Valve Mechanism. Valves set at an Angle.

The combination type of valve arrangement of course embodies the features of those just described. Fig. 16 can be applied to the valve in the pocket, while Fig. 17 would apply to the valve in the head or in the pocket when these are placed one above the other.

Various methods are resorted to in fastening the pushrod guides into the cylinders or case. They may either be pressed in position, held down in pairs by clamps or bolted down.

These various constructions may be applied to most any valve location. The principal change would come in the crank case, which is dependent upon the number of camshafts that are necessary to operate the valves. Enclosing the valve stems and pushrods is now quite popular.

Fig. 19 illustrates a bottom view of a T-head crank case in which the two camshafts with the respective parts are clearly shown. This view also shows a three-bearing crankshaft with

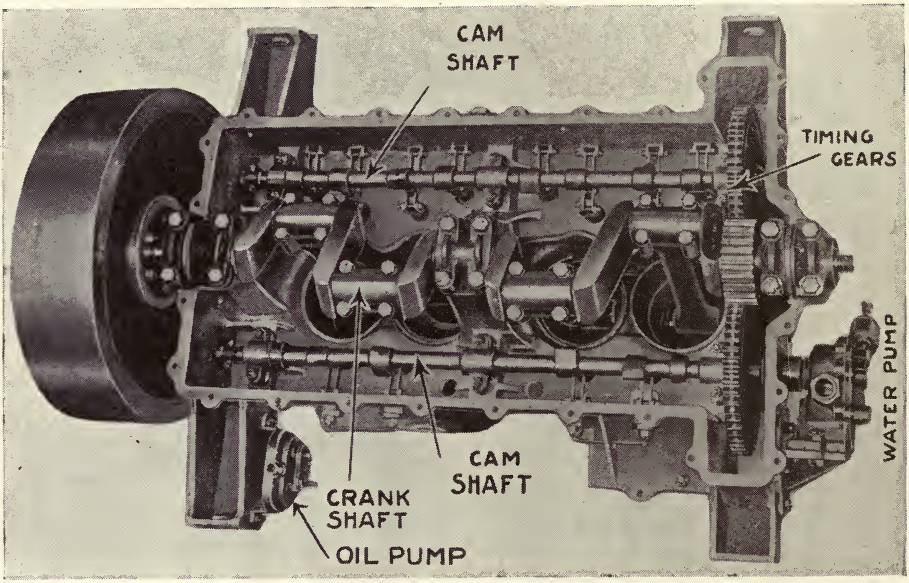

Fig. 19. Bottom View of a T-Head Crank Case, Showing two Cam Shafts.

the connecting rods fastened in position on the shaft and in the piston. The case is divided and all bearings are held in position by separate caps, while the cams are of considerable width, as the exhaust camshaft can be moved longitudinally so as to provide a compression release for cranking the motor. This is accomplished through the use of stepped exhaust cams which open the exhaust valve part way during a portion of the compression stroke while cranking the motor. The water pump is located at the front end of the motor and is driven through separate gears meshing with camshaft gears. The oil pump is located on the rear motor arm and is driven through a ratchet and link connection with a valve pushrod.

Fig. 20 illustrates a bottom view of a crank case for the L-head motor. It shows the camshaft and crankshaft in position, with the connecting rods mounted on the crank pins. But one cam-

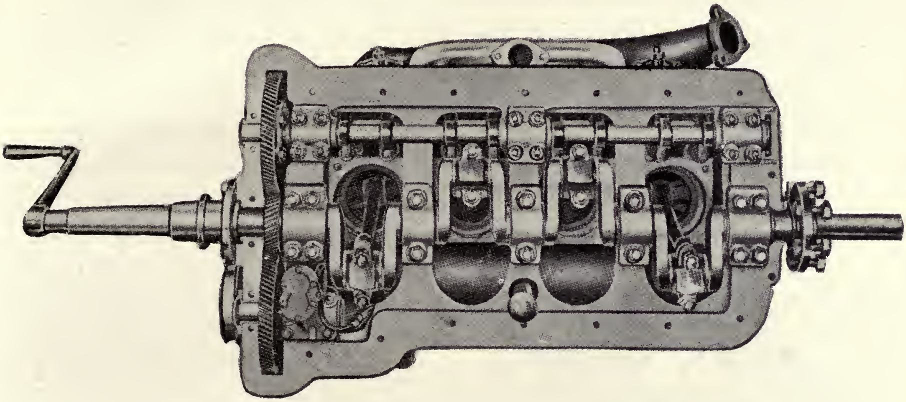

Fig. 20. Bottom of Crank Case of L-Head Motor.

shaft is used, and is driven through helical gears, the accessories are mounted on opposite sides and also driven through helical gears. The crankshaft is of the five-bearing type, while the case

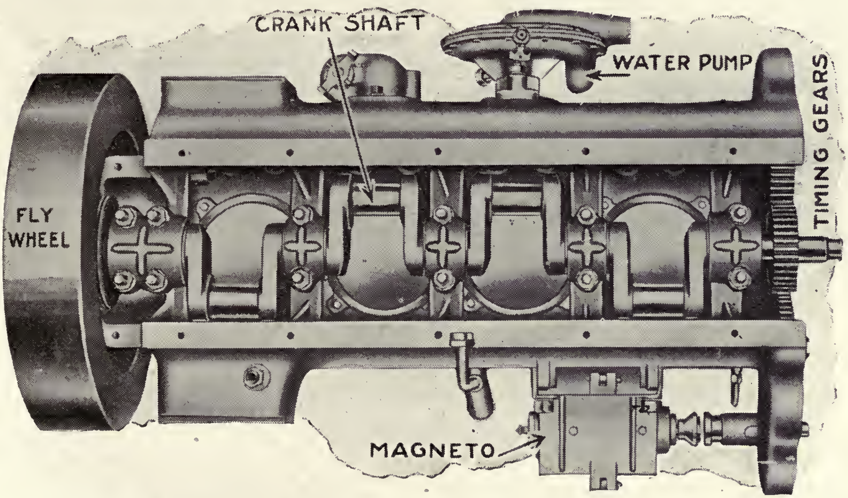

Fig. 21. Bottom View of Crank Case having Separate Compartment for Oil.

is divided on the horizontal center of the crankshaft, all the important parts being carried in this upper half of the case, the lower half serving only as a dust protection, oil splash basin and reservoir.

Fig. 21 illustrates the bottom view of a prominent valve in the head motor, with a three-bearing crankshaft and one camshaft for operating the valves. This crank case differs somewhat from the above in that it is cast in one piece with a separate oil reservoir bolted to it. The timing gears are carried in a housing at the front end of the case, enclosed by a steel cover plate. The magneto is driven from the timing gear housing through flexible couplings in the conventional way, while the pump is driven through spiral gears from the camshaft.

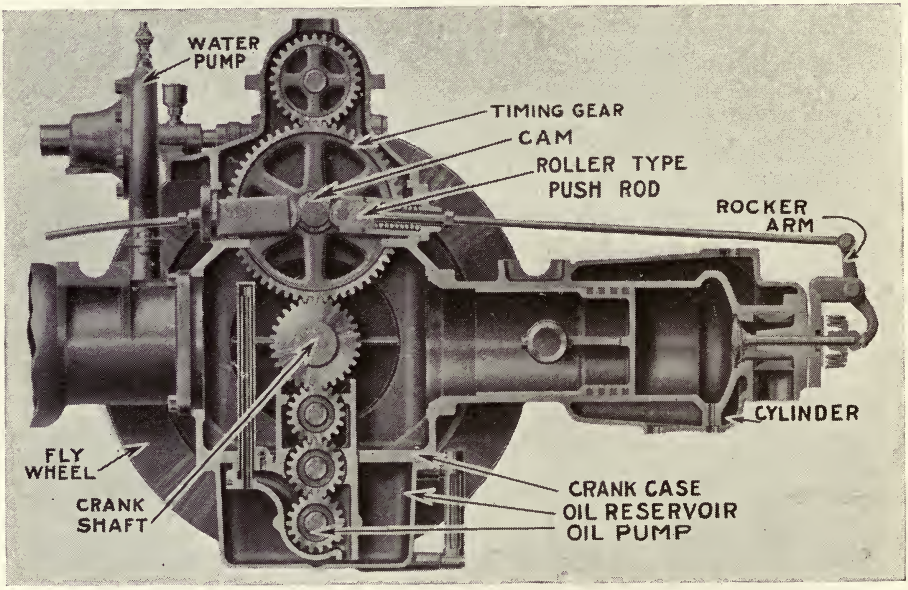

FIG. 22. Sectional View of Two Cylinder Opposed Motor.

Fig. 22 shows a sectional view of a two-cylinder opposed motor. This type of motor is mostly used on the light commercial vehicles, and the case is generally made from cast iron. This case is cast in one piece with circular openings on the ends, through which the crankshaft is inserted. Plates are mounted in these openings and bolted to the case which carries the crankshaft bearings. A large cover plate is used, which carries the camshaft, gears and pushrods. The water pump is driven by the camshaft bevel gears, while the oil pump is driven through an idler gear from the crankshaft.

In some of the two-cylinder motors in use at present the case is divided on the vertical center of the crankshaft and each half is cast integral with a cylinder, while the pushrods and camshafts are also located in the case instead of on the cover plate.

In the two-cylinder opposed type of motor the distance between the crankshaft and the camshaft is generally greater than the distance between the valve and the cylinder centers. This is due to the fact that in this type of motor the camshaft is located at right angles to the cylinder axis, while in the vertical motors it generally makes an angle of 45 to 60 degrees with the cylinder axis. The former case makes it necessary to either place the valve chamber farther from the cylinder axis, thereby increasing the length of the valve passage and consequently the compression space wall area, which is not good practice, or to offset the valves from the camshaft center and to provide the pushrods with an overhanging striker. In Fig. 22 the pushrods are set at an angle to overcome this point, which in this case is easily accomplished, as the valves are carried in the head of the cylinder and operated through a rocker arm.

Motor Lubrication.—Developments in the line of motor lubrication as a matter of course follow on the heels of progress in the art of motor design and construction, for the increase of efficiency which marks the refinement of the motor and its various parts can only be reached if the refinements are paralleled by those essentials which permits the units to perform their required duty. In commercial car motors, the two features, outside of actual mechanical construction and the essential details of ignition and carburetion, which help to the attainment of the highest results with the least expenditure are the cooling and lubricating systems.

The functions of the cooling system are different from those of the lubricating system and will be considered in a separate article following the present one.

All parts which rub together under pressure, such as the pistons moving upward and downward within the cylinders, the connecting rods on the piston and crank pins, the crank shaft in its bearings and all reciprocating and revolving parts must be efficiently lubricated. Whenever two surfaces are in contact and one or other is free to move when a force is applied, there is present a certain amount of friction, which develops instantly when these surfaces are not properly lubricated.

Friction is a resistance to motion of two bodies in contact and is dependent upon certain laws. It will vary in proportion to the pressure applied when the rubbing velocity remains constant. All wearing surfaces, no matter how carefully prepared, are known to consist of minute lumps and hollows. This is true, even of the smoothest surfaces that can be made, although, of course, the height of the depressions and hollows varies with different materials and the finish. The condition of bearing surfaces in an exaggerated degree may be likened to the nap of woolen cloth and the pile of velvet.

When the two surfaces are held in contact by an appreciable force these minute parts of the surfaces interlock and resist relative motion. This force is called the force of friction. This fact can easily be demonstrated by placing a book upon a table or smooth board and moving it across the latter, comparing the difference in energy required to move the book across the surface by placing a weight upon it. If this experiment were conducted with two metallic objects and the surfaces were lubricated, considerable less energy would be required.

Friction in reality is heat, which in a short period of time will reach an intense degree and in time the surfaces will be broken down and if the rubbing continues they will be completely destroyed. The action and effect of this friction upon two surfaces not properly lubricated may be explained as follows: At first small particles of metal are torn from the surfaces and these cut and abrade the bearing. As the surfaces continue to roughen, the friction increases enormously until it reaches the fusing point of the metal, when the two surfaces will weld into one solid mass.

A lubricant should possess certain qualities, since its object is to flow between the surface of a bearing, reduce its friction and to radiate a certain amount of heat generated by the bearing. These properties are termed adhesion, cohesion or viscosity, a high flash point and a comparatively low cold test point. It should have considerable adhesion so that the molecules of oil will cling together, considerable cohesion or viscosity, as all bearings are subjected to a pressure, created by the force acting upon them and the effect of this pressure is a tendency to separate these molecules forcing sufficient lubricant out of the bearing to allow the metals to come into contact.

The advantage of a high flash point is that the oil will not give off an inflammable vapor at ordinary temperature, while it should have a low cold test point, so that it will stay in fluid state when cold temperature are encountered. The high flash point is very desirable; for in lubricating the cylinders, the oil comes in contact with the walls of the combustion chamber and the heat in the cylinder on the power stroke. If the temperature is raised sufficiently to vaporize the oil, the viscosity is entirely overcome and the various residue products of the lubricant are deposited on the walls of the combustion chamber. This residue product is termed carbon and in time will harden, become incandescent and fire the charge prematurely, causing excessive strains on the various parts of the motor. The final result is that the motor will begin to pound, overheat very easily, the valves will pit and the spark plugs become fouled.

The advantage of a low cold test point is that it will flow freely in cold weather, preventing the oil leads and pump from clogging up.

There are various methods of lubricating the working parts of commercial car engines, and it is a difficult matter to classify them. We may distinguish, however, between the following: Plain splash; splash from constant level troughs with pump circulation; part force feed and part splash; force feed without splash; either from an external source or built into the motor.

The simple splash system was much used on the earlier models of commercial cars. The crank case contained a supply of oil into which the connecting rods dipped at each revolution of the crank pin, thereby splashing oil over the interior parts. As the oil worked out through the bearings or past the pistons, the oil level in the crank case fell and the splash became weaker. When the operator considered that the oil level had become too low, he would replenish the supply by either pouring oil into the crank case through a filling hole or transferring it from a supply tank to the crank chamber by means of a hand pump provided for the purpose.

The disadvantages of this system are apparent. The oil level varied constantly and so did the rate of supply to the bearing surfaces. When the crank case was replenished, the oil level was raised considerably and the supply to cylinder walls was generally excessive and the motor, in consequence, would pour dense smoke out through the muffler. In order to overcome this feature, some makers placed baffle plates between the cylinder and the crank case with an opening in the form of a rectangular slot for the connecting rod to pass through. Moreover this system required frequent attention from the operator, and if the latter were careless, the motor could easily be injured through the lack of oil.

Through the deficiencies mentioned above, lubrication by multiple feed mechanical oilers came into vogue. These oilers consisted of an oil reservoir carrying a series of plunger pumps, which forced the oil through individual leads to each part requiring lubrication. Each lead had its own pump, so that the oil was forced to each bearing in proportion to the speed of the motor. While this system was effective, its complications were objectionable. It was difficult to obtain a positive drive and the maze of oil tubes running from the oiler to the engine, rendered access to the latter difficult and presented a frail and non-mechanical appearance. It was also difficult to prevent leaks at the various connections and considerable oil was wasted.

Following this the pump circulating systems were introduced, as it was felt that a simpler system was needed and one that was at the same time thoroughly automatic. The gear and plunger types of oil pumps are most popular; however in some cases vane pumps are also used.

The gear pump consists of a casing in which fit snugly two spur gears, one driven by means of its shaft and gears from the cam shaft and the other by meshing with the former. The oil enters the housing on the side on which the meshing teeth separate and fills the spaces between adjacent teeth and the wall of the housing. It is thus carried around to the opposite side of the housing and leaves through an opening there.

Plunger pumps are generally placed inside the crank case and driven by eccentrics from the cam shaft. They consist of a brass barrel set in the case and carrying a plunger, which is held in contact with the eccentric by a spring. Below the spring a ball valve is placed. As the plunger moves upward, the lower end of the barrel increases in volume and oil enters through the ball valve. When the plunger is next moved down by the eccentric, the ball valve closes and oil is forced up through and out another ball valve, which remains closed on the upward stroke of the plunger.

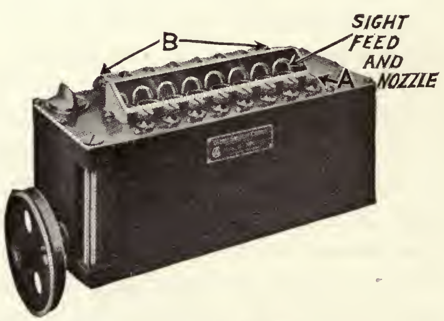

Fig. 23. Exterior of a Mechanical Oiler.

In what follows the writer will attempt to describe and illustrate the most popular systems in use at present, among which both the gear and plunger types of pumps will be found.

Fig. 23 shows a mechanical oiler which operates in the following manner. A series of double plunger valveless pumps are driven by belt from a cross shaft which is driven by the engine. One set of plunger pumps lift oil from the reservoir and discharge it from the nozzles in the sight feed compartment, the amount of oil discharged being regulated by the adjusting screws *A*, directly in front of the sight feed. The other set of plungers take oil from the sight feed compartments and deliver it to the various parts of the engine through the oil lead connected with the pump outlet *B*. The plungers work alternately and each acts on a check valve for the other.

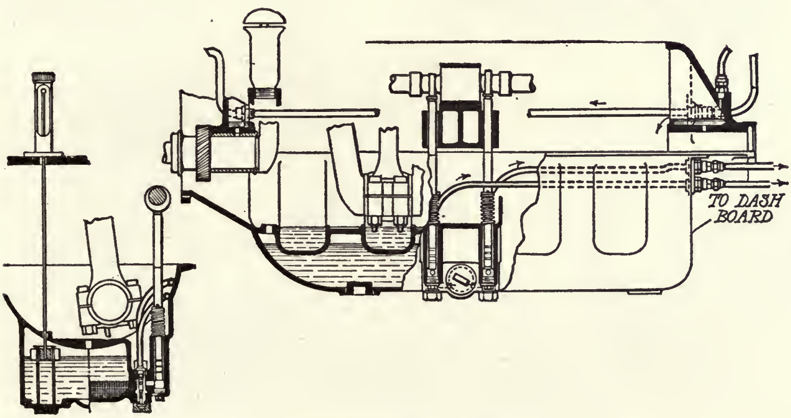

Fig. 24. Recirculating Splash System of Lubrication.

Fig. 24 illustrates a circulating splash system which has been used for a number of years on a prominent motor. Two plunger pumps are located in the lower half of the case and driven by eccentric from the cam shaft. One pump supplies oil to the timing gear compartment, and from these points it overflows to the splash troughs cast integral with the case.

The connecting rods are provided with dippers which are hollow and permit a certain amount of oil to reach the connecting rod bearings during each revolution of the crank pin. They also splash oil over the interior parts of the motor, the crank and cam shaft bearing housings being provided with pockets which store the oil and feed it to the bearings as it is needed.

Each connecting rod has a separate trough into which it dips, and the two forward ones are separated from the rear by a high partition, so that a positive oil level can be maintained for all conditions, when traveling up or down grade.

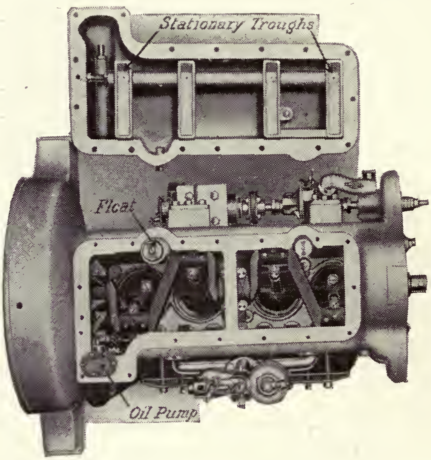

FIG. 25. Base Removed on Constant-Level Splash Lubricated Motor.

Fig. 25 shows another constant level splash system of the recirculating type. The operation of the system is similar to the one explained above, oil being supplied to the stationary troughs by a gear pump. Scoops on the connecting rods dip into these troughs and cause the oil to splash onto the pistons and into the small reservoirs which lead to the various bearings. The surplus oil drains back to the main reservoir, when it is thoroughly strained and again recirculated.

Fig. 26 illustrates a gravity-feed system using a gear pump for supplying oil to the gravity tank from the reservoir in the lower half of the case. This gravity tank is placed at the top level of the cylinders and has an oil lead of large diameter to each of the main bearings and the timing-gear compartment. The delivery pipe and leads are provided with strainers, so that the oil is thoroughly strained before being recirculated. The crank shaft journals and short arms are drilled through, so that the oil can pass from the main bearings to the connecting rods, centrifugal force being relied on to carry this oil to the connecting rods. Part of this oil works through these bearings and creates a spray, as in the force-feed system. This spray lubricates all other moving parts. It will be noted that the shape of the oil tank is such that when the car is moving up or down grade all bearings will receive an equal amount of oil. An oil gage on the dash shows the amount of oil in the tank, indicating that the pump is doing its work.

Fig. 27 illustrates a sectional view of a full force feed system of lubrication which is built into the motor. Oil is carried in a reservoir bolted to the crank case and is circulated by a gear pump mounted at the rear end of the case driven from the cam shaft. The pump forces oil up through a pipe over the main bearings and is provided with a pressure relief valve. This dis-

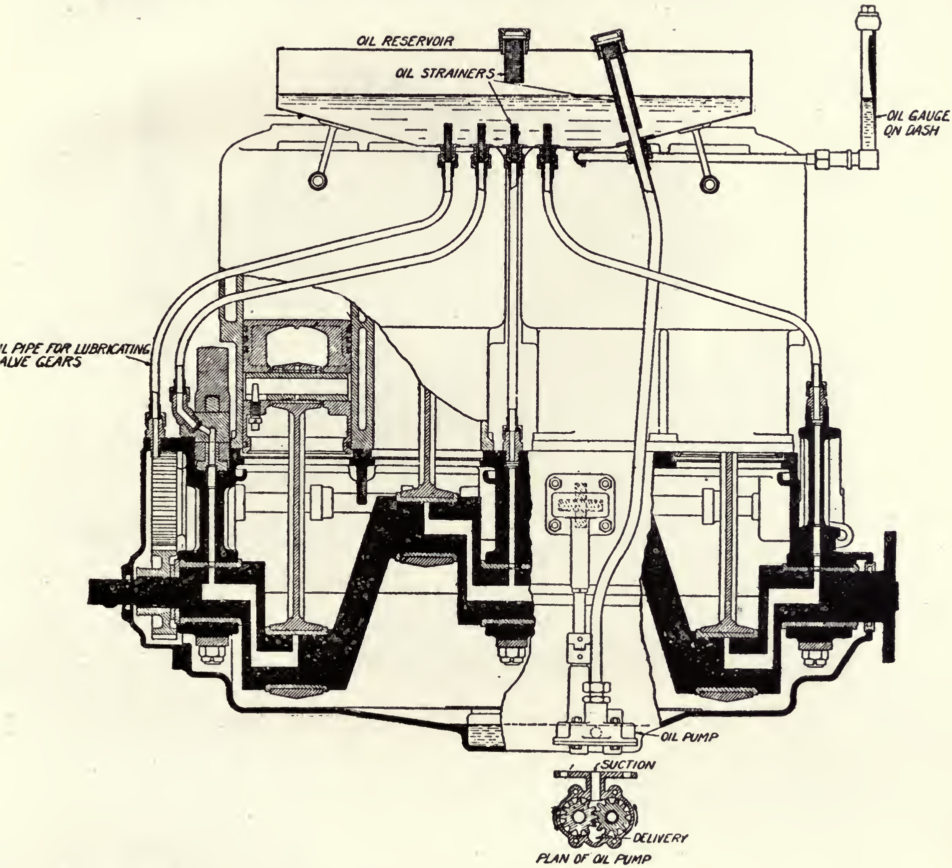

Fig. 26 Combination Pump and Gravity System.

tributing pipe has branches which communicate with the main bearings and the timing gears. From the main bearings the oil is forced through a hollow crank shaft to the connecting rod bearings. These connecting rods have tubes inserted in them so that the oil can be forced up to the piston pin bearings. Cam shaft bearings are lubricated by means of passages connected with the system. A certain portion of the oil works out from the connecting rod bearings, is thrown off as the crank shaft revolves and forms a fine spray which lubricates the cylinders, pistons and interior parts of the motor. An indicator which shows at all times the level of oil in the reservoir is placed adjoining the combination breather and filling tube. The oil pump and its strainers are removable from the lower half of the crank case without dis-

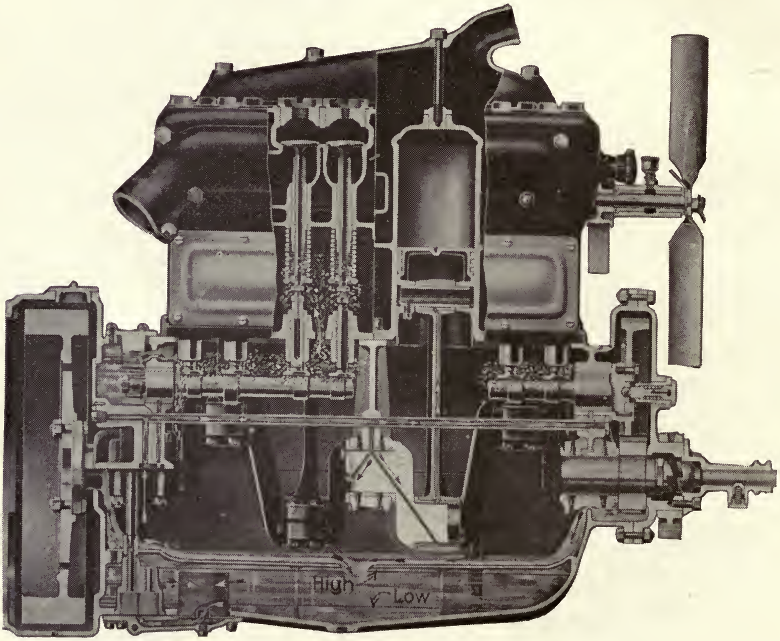

FIG. 27. Full Force Feed Lubricating System.

turbing other parts. The pressure relief valve permits a certain oil pressure on the bearings. Should the pressure exceed this predetermined amount the relief valve will open, permitting the excess oil to return to the reservoir. Oil which overflows and accumulates in the case flows into a trough into which the connecting rods dip. This trough has holes on one side which allow the oil to drain back to the reservoir beneath so that a constant level of oil is maintained.

Fig. 28 illustrates the Mack oiling system which is a combination of the gravity and force feed type. Oil is pumped from the reservoir at the bottom of the crank to a tank cast integral with the front pair of cylinders. This tank is provided with a filter and an overlow which leads to the timing gear housing. This tank serves two functions: first, to heat the oil while the

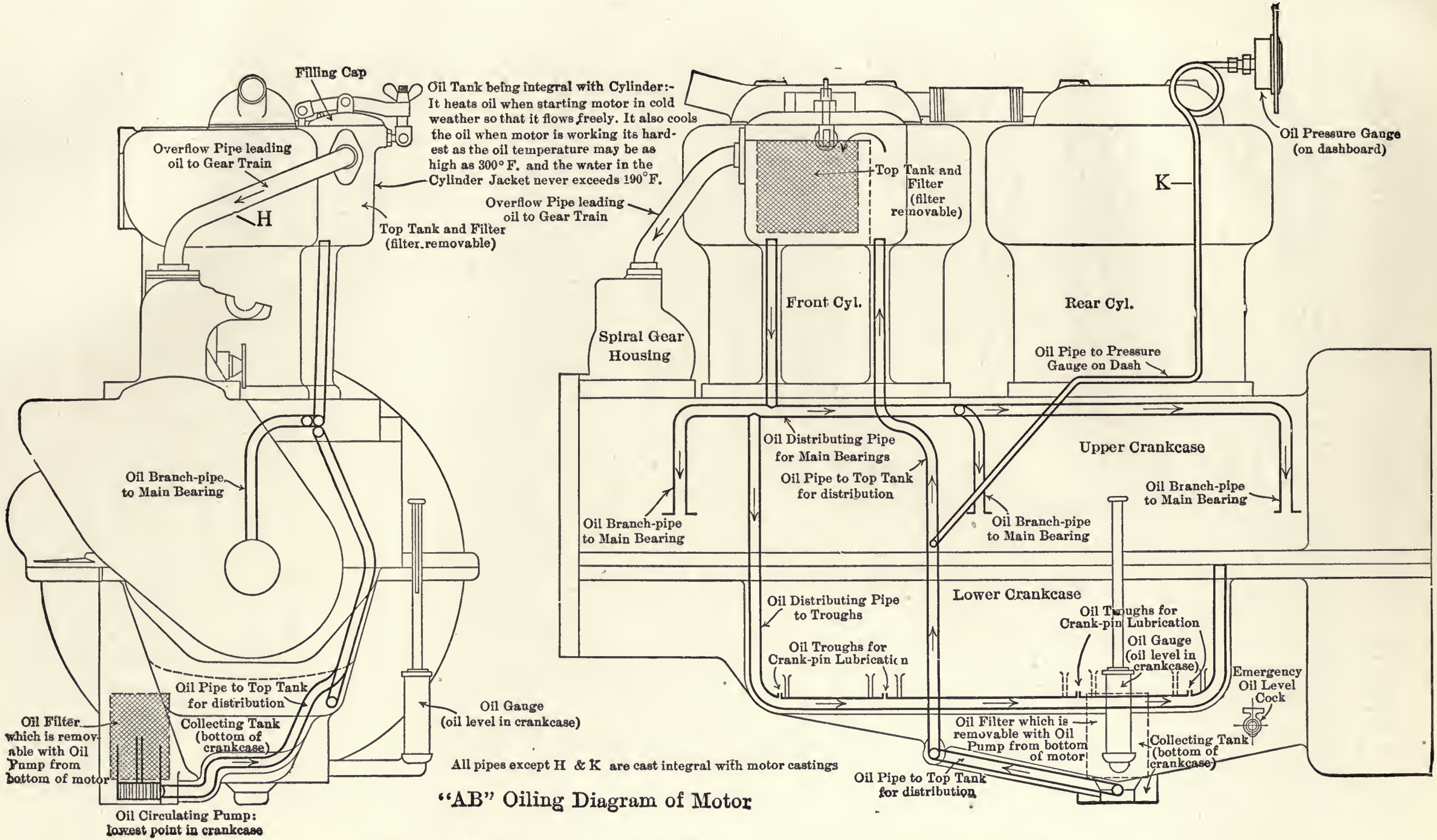

FIG. 28. Mack Oiling System—Combination Gravity and Force Feed.

engine is cold so that the oil will flow freely and second, to cool the oil when the engine is working hardest, as the oil may reach a temperature of 390 degrees Fahrenheit, while the cooling system seldom reaches a temperature higher than 190 degrees Fahrenheit. From the tank the oil flows to a main header which supplies oil to the main bearings and through a second header which supplies oil to the troughs into which the connecting rods dip. A pressure gauge is used to indicate the oil pressure and the pump is provided with a strainer to filter the oil before it is recirculated.

The constant level splash and force feed systems are the most popular, and as positive driven pumps are resorted to, to feed the oil, the general tendency is to provide oil leads of a large diameter and to reduce the number of bends to a minimum. Whenever bends are necessary they should be made as large as possible to reduce the obstructions and resistance.

From the above it can readily be understood that the writer considers the constant level splash recirculating system the simplest in use at present. Its operation is mechanical and the attention required is reduced to a minimum, while at the same time it is quite economical on oil.

The advantages of the force feed system are that the oil may be forced to the bearings under separate pressure, reducing the danger of the oil being forced out by the bearing pressure. It is generally agreed that with force-feed the specific pressure on the bearing can be increased and that the bearing will last longer, while on the other hand the writer finds that this system is more expensive to install and less economical of oil. It would appear to be better adapted to commercial car engines which operate at or near their full load for a considerable length of time.

In the gravity feed system the oil leads must be carried on the outside of the motor, which presents some complications, as they will require attention at intervals. The economy is possibly on a par with the constant level splash system. Mechanical oilers are very rarely used on the types of commercial cars, being practically obsolete.

CHAPTER III

THE MOTOR COOLING SYSTEM

Continuing from the previous chapter we can next investigate the cooling system, considering first the office of the cooling system. This system must cool the cylinder walls to such an extent as to permit of the proper lubrication and to prevent the carbonization of the lubricating oil. Preignition will also occur if the metal is permitted to heat to a red heat, causing the gas to ignite on the compression stroke. It is the general impression that the office of the cooling system is to abstract the heat from the gases within the cylinders, this heat having been generated by the explosion. This is not the case, for, as a matter of fact, the duty of the cooling medium is to keep the cylinder walls cool, the heat of the gases being converted into useful energy.

The Direct or Air System.—There are two general types of cooling systems, the direct or air system and the indirect or a system using a cooling medium such as water or oil. The term direct is applied to the air system, as there is no intermediate transfer of heat from the cylinder walls to the radiating surfaces by means of a cooling liquid. Air cooling is generally effected by cooling ribs or fins as they are sometimes called, cast integral with the cylinder walls and head. Some mechanical method, such as mounting a fan at front of the motor, or combining it with the fly wheel, is generally resorted too for inducing air circulation. Fig. 29 illustrates a typical air cooling system. This type of cooling system is most popular on the low-priced vehicles using two, three and four-cylinder motors. It may be used on either two or four-cycle motors.

The Indirect System—Water or Oil.—The indirect cooling system as mentioned above involves the circulation of a liquid such as water or oil, to absorb the heat and deliver same to a current of air which is passed over the surface of the radiator within which the liquid in its heated state is circulated. At present water is used as the medium in all indirect systems. Oil was used in some cases, but it presented serious disadvantages. Water may be circulated in two ways, first by the natural system which is termed the thermo-syphon system, and second under pressure through the use of a suitable pump driven by the engine.

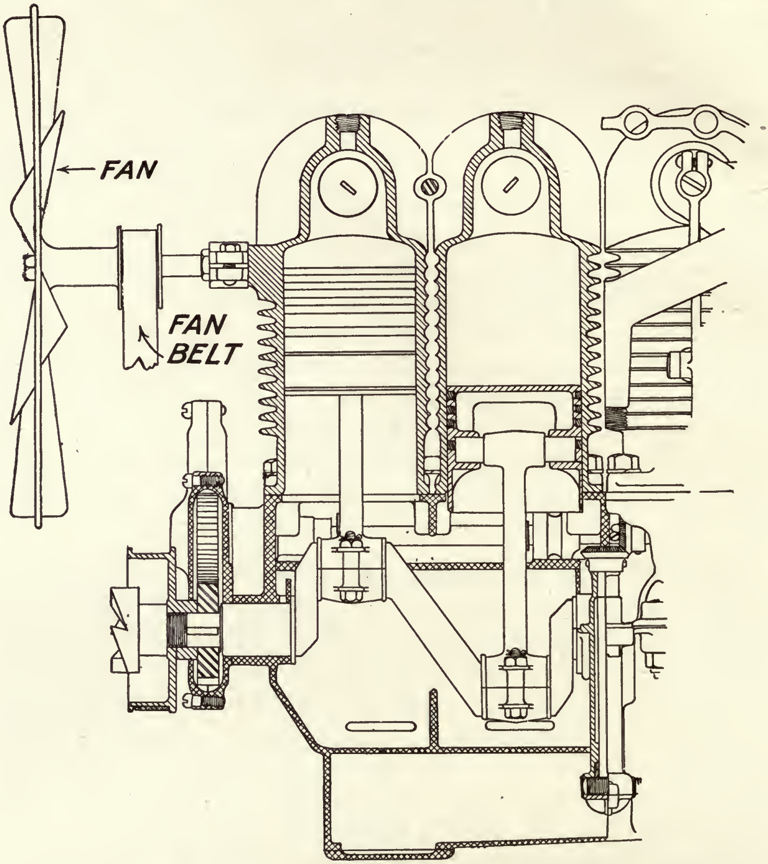

FIG. 29. Sectional View of an Air-Cooled Motor.

The indirect system may be described as follows: Water is circulated from the lower water tank of the radiator through a distributing manifold to the lowest point of the cylinder water jackets, and, as it becomes heated, its specific gravity decreases, rises and flows out through the outlet manifold located on the top of the cylinders, to the top of the radiator, passing into the upper tank. From here it is distributed to various water passages through which it passes to lower tank and is recirculated. These water passages are separated by air spaces for heat radiation.

In the forced circulation, a pump draws water from the lower tank and forces it through cylinders, as well as creating a pressure to force it through the water passages of the radiator. In the thermo-syphon system, the pump is eliminated and circulation is induced by the heat of the motor. The water under the influence of heat sets up a circulation. It can readily be understood that the heat replaces the pump and acts as the moving force on the water.

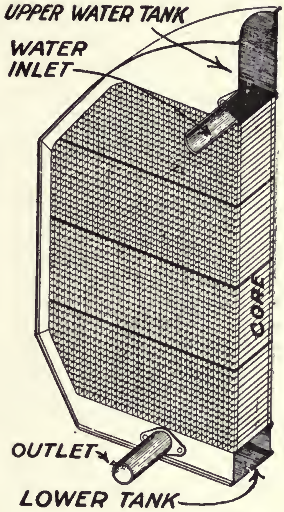

Fig. 30. Cutaway Section of Radiator.

Types of Radiators.—Many different types of radiators have been worked out since the early days of the industry. The types in use at present are termed the honeycomb, cellular, vertical tube and vertical tube built-up types. The radiator is necessarily comprised of an upper and lower water tank and the core in which the water is divided into small streams, which are separated by air passages for heat radiation as shown in Fig. 30. The type of radiator is generally defined by the type of core used.

The true honeycomb core consists of a series of six-sided or hexagonal-shaped tubes fastened into the water tanks in such a way as to allow of air space between the water passages. This type is frail and not to the writer's knowledge in use at present on commercial cars.

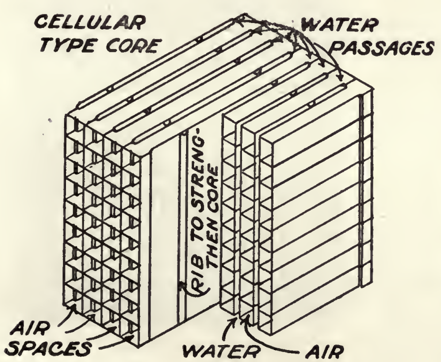

Fig. 31. Section of Cellular Type Core.

The more popular cellular core is often called a honeycomb. This consists of a series of square tubes placed either vertically or diagonally into the tank, forming a much more rigid structure. The vertical placing is more desirable, as this provides a continuous vertical tube from one tank to the other. It offers less resistance to circulation and is not so apt to clog up from dirt, rust and other substances. Radiating surfaces are approximately equal for either construction. This construction is clearly illustrated in Fig. 31.

The vertical tube type of core consists of a series of rectangular tubes fastened into the water tanks, with fins attached to them for heat radiation, as shown in Fig. 32. The fins also materially assist in strengthening the core, and in some cases they are made continuous so that the entire construction presents a very pleasing appearance, similar to the cellular type. This vertical tube type of radiator is very much in evidence on the popular-priced vehicles, as its first cost is considerably lower than the cellular type.

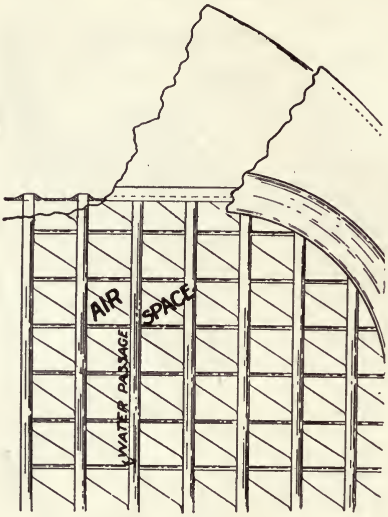

FIG. 32. Section of Vertical Tube Type.

During the past few years there has been a decided tendency to build up radiator cores from round copper tubes with separate round or square cooling fins and cast water tanks, the upper tank usually being provided with ribs to assist in heat radiation owing to thicker section of metal necessary in casting these tanks. This type of radiator is illustrated in Fig. 33 with a tubular core and cast columns between the tanks to relieve the core of the strains due to the weight of the tanks and water.

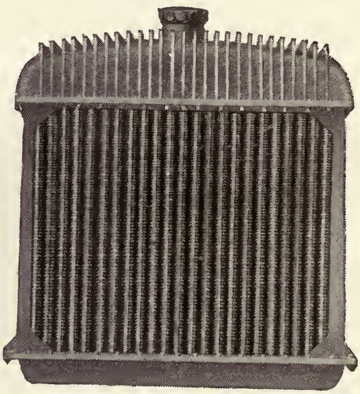
FIG. 33. Cast Water Tanks and Built-Up Core.

Another popular-priced truck uses this style of radiator. However, the tubes are fastened to the tanks by clamps in series of three. This construction presents an advantage in the simplicity of repair and the small cost of replacing these sections should they be damaged beyond repair. While this type of radiator presents some advantages in strength, the writer believes that it possesses a disadvantage in that it is not as efficient as the conventional style mentioned above. Only a certain portion of the tubes is exposed to the air currents, while the rear ones are naturally limited in cooling ability, owing to being obstructed by the forward ones. The volume of water is somewhat greater in these tubes for the same rate of circulation, so that the cooling effect is somewhat retarded. The writer has experimented with both types and has come to the conclusion that the conventional type is more efficient and will stand up under the most severe service when spring-mounted.

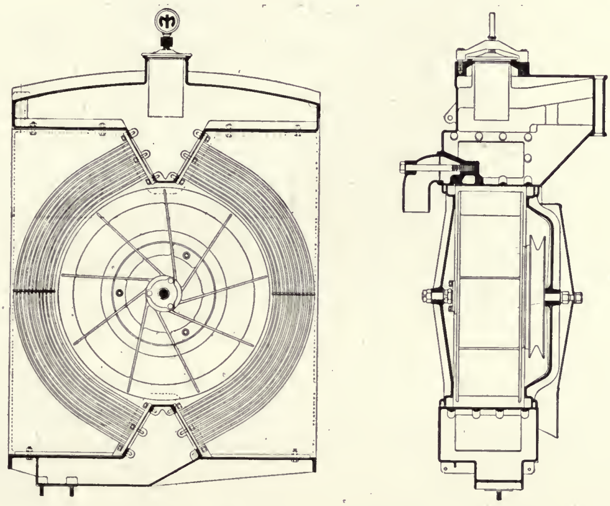

FIG. 34. Mack Model "AC" Built-up-Radiator.

An unusual radiator construction is shown in Fig. 34, which represents the Mack radiator for heavy duty trucks. By the use of a large number of practically semi-circular sections of copper tubes, which are expanded into plates that in turn are bolted to the upper and lower tanks, a solderless radiator is obtained, which expands within itself and withstands severe vibration without failure. Upper and lower tanks are of aluminum alloy and the upper tank forms part of the cowl, while the lower is part of the frame that supports the entire unit. The tubes are expanded into the plates and no solder is used in the construction. As each tube is a unit in itself, one or more of the tubes can be blocked, or pinched off in case of emergency without interfering with others. Instead of being placed in front of the engine this radiator is placed back of it.

Mounting of Radiators.—Radiators may be mounted in two positions on the chassis frame; either in front of the car so that the air currents pass almost unobstructed through the passageways, or in back of the engine against the dashboard, while on one particular chassis it is placed in the rear of the engine under the seat. Either of the latter two positions afford a somewhat more accessible engine and also afford a better protection for the radiator. However, this construction requires a proportionately larger radiator to obtain the same results as in the forward position.

In commercial car operation the heavy vibrations accompanying high speed on rough pavements and the distortion of the frame, place heavy strains on the radiator, so that it becomes necessary to mount it on springs and also provide a certain amount of universal movement to overcome frame distortion. These springs may be of flat spiral or coiled wire or of round or square section. This support is usually of a three-point type, so that a limited amount of universal movement is obtained.

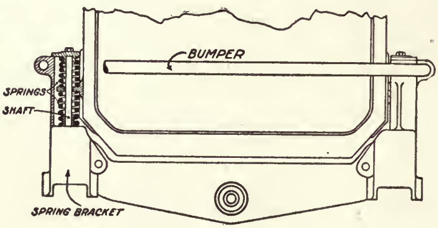

Fig. 35. Combined Enclosed Spring with Front Hanger Brackets.

Fig. 35 shows a popular type of enclosed spring mounting combined with the front spring hanger brackets. Brackets, riveted to each side of the radiator, have extensions, which are mounted between two coiled wire springs in each spring bracket. This bracket has a small cover plate which retains the springs, and, together with the spring bracket, supports a vertical shaft, which acts as a guide for the radiator brackets. The radiator brackets are drilled out larger than the shaft, to provide for a certain amount of universal movement. The top of

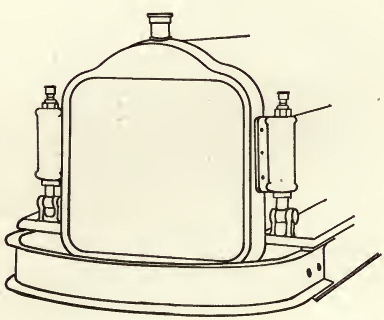
Fig. 36. Universal Enclosed Spring Mounting.

the radiator is further supported by a stay rod which is attached to the dashboard. A bumper extending from one spring bracket to the other protects the radiator core from being damaged by colliding with the rear end of other vehicles.

Fig. 37. Flat Spiral Spring Mounting of the Master Trucks.

Fig. 36 illustrates another type of spring mounted radiator. However, in this case a limited universal movement is obtained through a clevis joint on the frame bracket, while the bumper is set into the main frame channel.

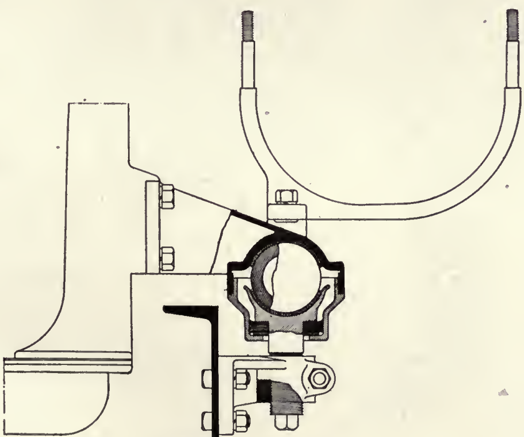

Fig. 38. Onieda Radiator Mounting.

Various constructions are resorted to in practice. However, they merely present different methods of accomplishing the same results.

Fig. 37 shows a construction using a flat spiral spring attached to the radiator. One end of the flat spiral spring is bolted to the upper flange of the frame member, while the other end is rolled into an eye. A bolt is inserted through the spring and side column to form a permanent fastening.

An excellent example of flexible mounting is depicted in Fig. 38 in which a pneumatic shock absorber is used. This shock absorber consists of a pneumatic rubber sphere placed within a chamber of elliptic shape, providing a perfect cushion and acts as a pivot, while it is perfectly enclosed and protected from dirt and grit. This sphere is protected against excessive wear by fabric pads set into the cups which form the chamber. These are free to roll in any direction on the sphere, thereby relieving all warping stresses, while the spheres take up all shocks and vibrations.

Types of Water Pumps.—There are four general types of water pumps: the gear, the centrifugal, the rotary or vane and the plunger types. The centrifugal is by far the most popular and

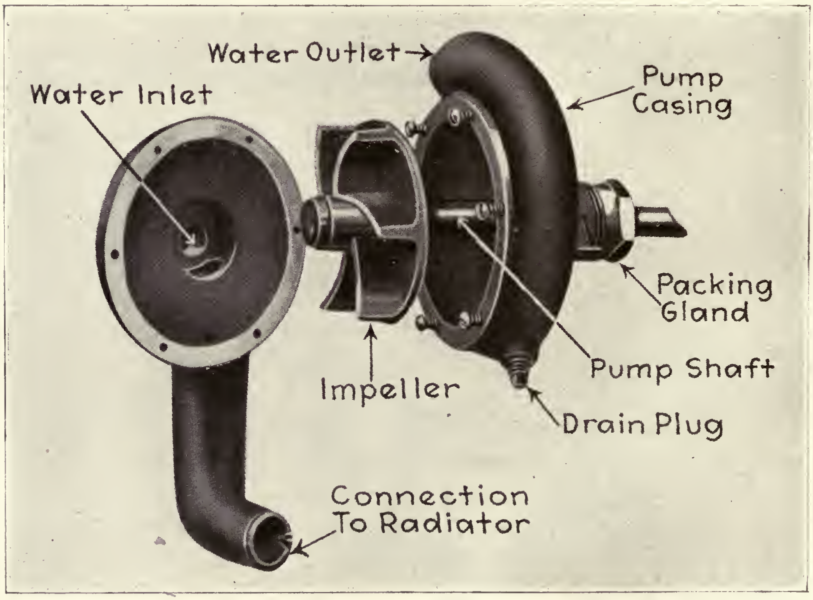

Fig. 39. Sectional View of Centrifugal Pump.

the gear type is next in popularity, while the rotary or vane type is very little used on commercial car motors. The plunger type is entirely confined to marine work, where it is used to better advantage.

The centrifugal type illustrated in Fig. 39 is perhaps the simplest of all and the easiest to understand. It consists of an impeller of paddlewheel which may either be formed integral with or keyed to the driving shaft and a case and cover which house the rotating member. In operation it is rotated at a high speed, the water entering at the center of the rotating member, flowing out on the arms or paddles and being thrown off by centrifugal force. This throwing off action is restricted by the case, so that the water is forced through the pump outlet.

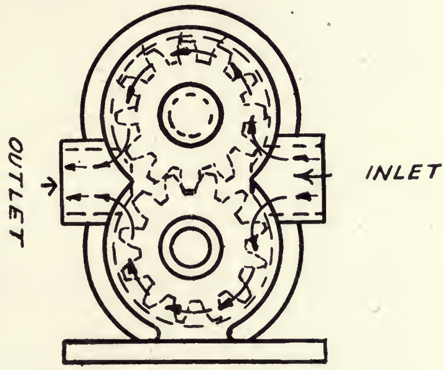

FIG. 40. Section of Gear Pump.

The gear type of water pump is identical with the gear type of oil pump, with the exception of being much larger. It is illustrated in Fig. 40 and it can readily be seen that it consists of a pair of gears, a pair of shafts for them to rotate on and a case with cover to serve as a housing for the gears and to carry the shaft bearings. The arrows illustrate how the water enters the housing through the inlet pipe and is carried around between the spaces of the gear teeth and forced out through the pump outlet on the opposite side of the inlet. This type of pump is quite simple and was extensively used on the earlier types of commercial cars.

Both the gear and centrifugal types of pumps possess an advantage over other types, in that they provide a continuous stream of water. Between the two there is very little or no choice, unless it is that the gear pump is more likely to become noisy. They both do the work under substantially the same conditions.

The rotary or sliding vane pump shown in Fig. 41 consists of a cylindrical housing in which is located a disc of a thickness equal to the internal height of the housing, but of smaller diameter. The disc is located eccentrically with respect to the chamber and is cut with a diametrical slot dividing it into two halves, in which slots are located two sliding vanes which are pressed apart by a flat spring between them, the action of the vanes being to carry the water around to the outlet as indicated by the arrows.

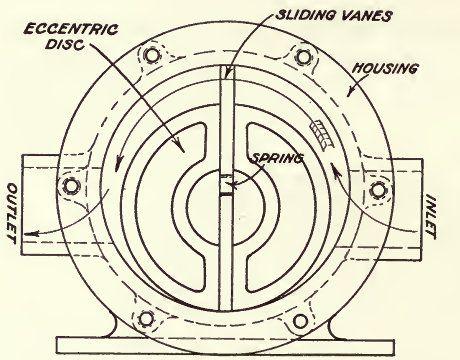

Fig. 41. Section of Sliding Vane Pump.

Water pumps are generally driven by shafts extending from timing gear housing and are provided with flexible or universal driving couplings. The couplings serve to keep the pump free from strains due to misalignment, and they are generally so designed that when the pump freezes up, the coupling will break before any damage is done to the pump parts.

Fans as an Auxiliary.—The motor must be cooled effectively regardless of car speed. To cool a commercial car motor under ideal conditions and most effectively would require a tremendously large radiator, if the car stood still and only natural air circulation were depended upon. To reduce the radiator to a size that can be used, the relative efficiency is increased through an artificial flow of air. This is brought about in two ways. One is that the radiator does not stand still, but is moved with the car, which induces an air circulation. However, this would not be effective with the car standing still and the engine running, so a second artificial circulation is provided through a fan. This fan is driven from the engine and rotates when the engine rotates. If the engine runs slowly and has little heat to dispose, the fan runs slowly. Again, when the engine is running at its maximum speed, the fan, too, is making its highest possible number of revolutions. The fan serves the same purpose in an air-cooling system, by forcing a draught of air over the cylinders in each revolution.

This fan is generally placed at the front of the motor and driven by belt from a pulley mounted on the crank shaft, cam shaft, or accessory drive shaft, and draws air through the radiator, while in the air-cooled system it draws air through a screened opening at the front of the hood.

Sometime ago there was a decided tendency to combine the fan with the flywheel, drawing air through the radiator and over the whole engine, thus effecting a secondary method of cooling. In some air-cooling systems the bonnets on the engine are provided with deflectors so as to direct the air currents to the rear cylinders, while one maker encloses the entire motor in a sheet steel housing, so the flywheel draws an equal amount of air over each cylinder.

CHAPTER IV

CARBURETION AND CARBURETORS

Carburetion is the term applied to the process of converting the liquid fuel into an explosive mixture. It comprises the vaporization of the fuel and the mixing of gasoline and air in the proper proportion to produce the explosive mixture drawn into the cylinders. The function of the air is to supply oxygen for combustion.

Air is a quantity of infinite variables, since its oxygen content for a given volume is proportionate to its temperature. The higher the temperature, the smaller the quantity of oxygen it contains, without any change of carburetor adjustment. It is accordingly advisable to use the air at the lowest temperature at which vaporization is possible.

The best proportion of air to gasoline varies between sixteen to seventeen parts of air to one of gasoline; however, this will be dependent upon the quality of the fuel.

Since the power of a gasoline motor is derived from the fuel which enters the cylinders during the suction stroke, it is of utmost importance that the mixture of fuel and air which is used by the motor, shall always be of exact proportions, so that when it is ignited by the spark, it will give the maximum force of explosion for a given quantity of fuel. If there is too much fuel or too little, within relative narrow limits, the action of the engine becomes objectionable.

Vaporization of fuel may be accomplished in two ways, by heat or vacuum; vaporization due to pressure reduction is distinguished from vaporization caused by the supplying of heat. In the vacuum method, vaporization is only partly complete, no matter how far the process of reduction is carried, since the part of the liquid, which vaporizes, does so through the abstraction of heat from the remainder, which becomes constantly colder until finally the temperature is so low, that vaporization ceases until heat is supplied from some outside source. When vaporization is brought about entirely by heat from an outside source, the degree to which it may be carried depends wholly on the amount of heat supplied, since the temperature of the liquid is being constantly raised to or maintained at the proper point.

In practice neither of the above processes are carried to the limit, but both act together. The reduced pressure, due to "motor suction," causes vaporization with a lowering of the temperature, and the heat of the air tends to cause vaporization through a transfer of heat from itself to the liquid. Each of these vaporizing actions assist the other; the air supplying heat to the liquid as it is cooled by vaporization under reduced pressure, and the reduction in temperature, due to pressure reduction, facilitating the transfer of heat from the air to the liquid.

The instrument which serves to carry out the above functions is known as the carburetor. Gasoline is stored in a tank, generally located under the driver's seat, and from here it is fed through a small pipe to a compartment of the carburetor called the float chamber, passing through a needle valve and strainer, which regulates the amount of gasoline entering the carburetor. To allow metal floats to be sustained in the gasoline they are made air tight and hollow, so that the needle valve can pass through them onto the valve seating. Somewhere near the top of the needle valve, small weighted arms are pivoted, the ends of which rest idly on the top of the float. The function of this float and chamber is to maintain a constant level of gasoline in its own chamber and the chamber in which the jet is located. The level in the latter chamber must be constant so as to prevent the gasoline flooding over the jet, which will cause faulty running of the engine. The action of the float is very much like an automatic water cistern, with its ball valve, for, as more gasoline enters the first chamber, the float rises, and with it the weights resting on it so that the needle valve is pushed down on its seating and shuts off the supply.

The other part of the carburetor called the choke tube, or mixing chamber, accommodates the jet and allows a stream of air to pass around it when the piston descends on the suction stroke. The float chamber maintains a constant level of gasoline in the jet. When the air rushes up around the jet, it draws with it a certain amount of sprayed gasoline, and, when the mixture of air and gasoline impinges on the sides of the inlet manifold, it becomes a gaseous mixture and enters the engine in this state through the inlet valve.

Just below the manifold flange of the carburetor, and in the choke tube, is located a throttle, which can be opened or closed by the operator from the lever on the steering gear or foot throttle. The more gas the engine can receive, the faster it runs, and the faster it runs, the more gasoline it is likely to draw from the jet. This would give an unduly rich mixture, unless means were provided for admitting more air, and thus giving the mixture approximately correct proportions. For this purpose an auxiliary air valve is provided, communicating with the choke tube just above the jet. As the engine speed increases, this auxiliary air valve opens and permits more air to enter, thus maintaining the proper mixture. It is a general assumption that more air must be admitted at high speeds, but this is not really correct; for, while we are admitting more air, we are merely endeavoring to keep the proportions of air and gasoline the same. Increased engine speed means increased suction on the jet, and naturally the liquid gasoline is drawn through faster than the air, so that more air must be admitted to compensate for the excessive suction. But apart from speed, temperature and humidity have their effect on carburetion. In the summer, the air parts require to be opened wider than in winter, as the atmosphere is less dense; also, when the air is damp and the barometer low, more air will be necessary.

The auxiliary air valves are generally suction operated, opening progressively as the suction increases from higher speed or some other cause. If these valves could be made to have no inertia, they would follow the suction exactly and their action would be ideal. But the fact is that they open and close late. Added to these faults, is that there is no way of operating them that is not subject to variation. If springs are used they will change in strength. A weight is effected by vibrations of the car, as is also a mercury bath with a float, though to a less extent. In fact numerous methods have been experimented with and all found lacking in some respect.

There are many different makes of carburetors in use on commercial car engines at present. All carburetors which are used at the present time work by controlling the flow of gasoline in proportion to the air demand, some attempting this by raising the gasoline needle valve with the increased demands of the motor, such as the Schebler and Breeze carburetors; and others accomplishing this indirectly through various air regulations and auxiliary valves, as in the Kingston, Stromberg and others.

Some carburetors operate automatically, while others are so arranged that they may operate both automatically and mechanically.

This principle of automatic carburetion, which is employed in the majority of modern carburetors, may be outlined as follows:

A correct mixture having been obtained for the minimum suction on which the motor is capable of running, is compensated by the introduction of additional air at a rate varying automatically with the suction. The mechanical operation is obtained by connecting the butterfly valve, which controls the admission of gases from the carburetor, with the butterfly valve in the main air opening, the automatic operation of the auxiliary valve being retained.

During the past year there has been a tendency to provide dashboard adjustments, so that the mixture may be instantly varied throughout the entire range for heavier or lighter work, or because of other changing conditions. This is generally accomplished by varying the pressure of the auxiliary air valve spring. They are quite an advantage, as it is claimed that an automatic carburetor cannot adapt itself to changes in gasoline density, or in humidity, or to the gradual warming up of an engine when started from cold.

It would require too much space to illustrate all the various makes of carburetors used on the various commercial car engines, so the writer will present a few illustrations, which are explanatory of the various types discussed in this article, such as the raised needle valve type, the indirect type, and automatic and mechanically operated types.

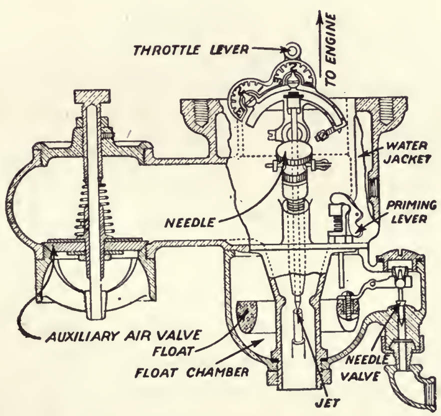

Fig. 42. Sectional View of Schebler Carburetor.

Fig. 42 is a sectional view of the Model "L" Schebler carburetor, which is of the raised needle type, and is so designed that the amount of fuel entering the motor is automatically controlled by means of a raised needle seating in the jet, working automatically with the throttle. The float and its chamber surround the main air supply in which the jet is located. The jet opening is controlled by a needle, which permits of a variable opening as the throttle is opened or closed, being operated by a cam on the throttle lever. The auxiliary air valve is controlled by the suction of the motor, while the mixing chamber is water jacketed to apply heat to assist in vaporization. The main air supply can also be connected with a drum around the exhaust manifold for supplying warm air.

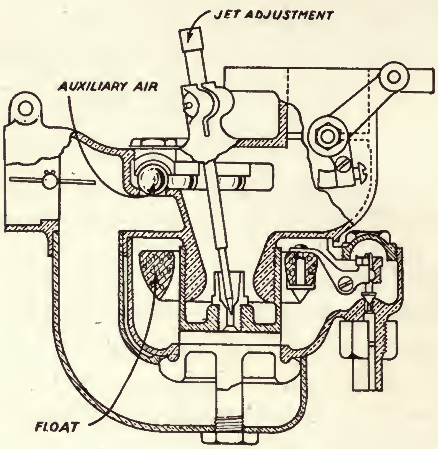

Fig. 43. Section of Kingston Carburetor.

Fig. 43 is an illustration of the Kingston carburetor, which is provided with an adjustable jet surrounded by the float and chamber. The main air intake communicates with the mixing chamber, while the auxiliary air enters through five circular openings arranged in a semi-circle above the mixing chamber, and controlled by floating balls. These balls are so arranged that they cannot become displaced. They operate automatically, gradually lifting from their seats as the motor suction increases. The air passing the openings guarded by the balls has an unrestricted passage into the mixing chamber, and then to the motor. The main air intake is fitted with a butterfly throttle, so that the amount of air can be reduced for starting, around the nozzle of

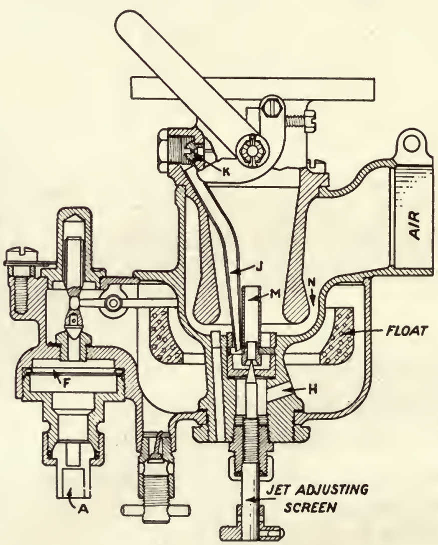

Fig. 44. Holley Carburetor in Section.

the jet, is a well, which becomes partially filled with gasoline while the motor is idle. This is brought about automatically by the level of the gasoline in the float chamber being slightly higher than the top of the jet. This gives a rich mixture for starting, and as long as the motor is running the gasoline is drawn through the jet into the intake manifold, the well remaining dry.

Some of the features of the Holley carburetor, illustrated in Fig. 44, are concentric float, adjustable jet, supplementary standpipe for starting and slow running and absence of air valves. Gasoline enters and passes through a strainer *A* and passages *H* into the jet. This jet is controlled by a milled screw, so that the opening can be varied at will. Gasoline passes into the jet *M*, which is in the shape of a venturi, or double-ended cone, and also into the standpipe *J*, to a level determined by the float. This standpipe leads to the edge of the butterfly throttle, and when the latter is closed, the suction of the motor allows gasoline to be drawn up into the standpipe, past the plug *K*, and into the manifold. After the motor has been started, and the throttle opened, the gasoline is drawn through the main jet *M*, mixing with the air that enters from below, through the conduit *N*.

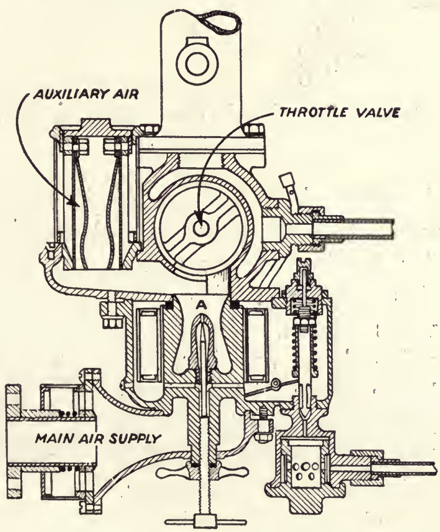

FIG. 45. Section of Pierce-Arrow Carburetor.

Fig. 45 illustrates the Pierce-Arrow automatic carburetor, with concentric float and adjustable jet. The gasoline supply from the tank passes through a fine gauze strainer, preventing water and dirt from entering the float chamber. The main air supply is taken through the lower inlet, and, coming from the proximity of the exhaust pipe, is warm, and passes up around the spray nozzle *A*. The auxiliary air is taken through two reed valves, which are controlled by flat springs. When the engine runs slowly, both auxiliary valves remain on their seat, and as the engine runs faster, the more intense suction opens the lighter reed valve, admitting air above the spray nozzle. A further increase in engine speed opens the heavier reed valve, permitting still more air to enter.

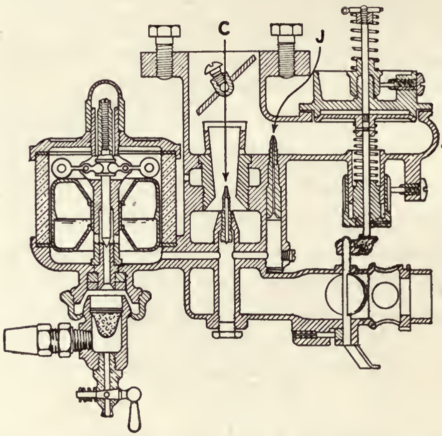

Fig. 46. Sectional View of Stromberg Carburetor.

The Stromberg carburetor (Fig. 46) is a double jet type, featuring an eccentric float chamber with a glass wall, a feature which is typical of all Stromberg models. The flow of gases is controlled by a butterfly valve placed over the mixing chamber and immediately over the venturi, in which the main jet *C* is located. The second jet, *J*, comes into operation as the speed of the motor increases enough to permit the auxiliary air valve to open. The main air passage can be entirely or partially closed for starting purposes, and this operation also prevents the auxiliary air valve from opening, the latter being of the mushroom type, provided with two adjustments. The valve has two spindles, one above and one below the seat, each spindle having a spring encircling it, finer adjustment being claimed for this construction. The body of the carburetor is not water jacketed, heat being supplied through the open air pipe from a drum surrounding the exhaust manifold.

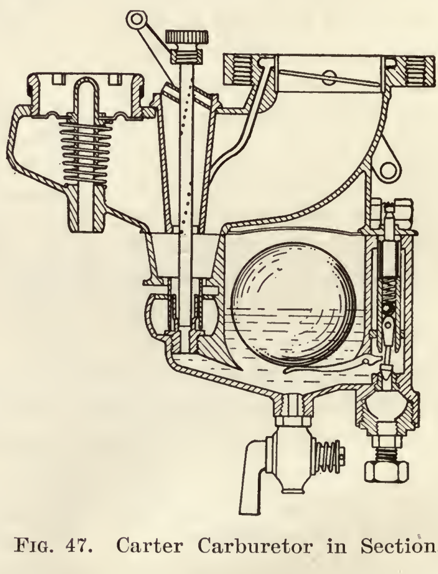
Fig. 47. Carter Carburetor in Section.

The features of the Carter carburetor, illustrated in Fig. 47, are eccentric float, shock-absorbing needle valve control and vertical multiple jet fuel tube. Gasoline enters the float chamber in the usual way. However, the needle valve is provided with a small shock-absorber, as no permanent connection is made between the float and the lever controlling this valve.

The tube, located in the funnel, has a multiplicity of small holes arranged spirally around the tube, and, as a vacuum is created in the carburetor by the suction of the motor, the fuel rises and falls instantaneously in the tube, according to the speed of the motor. As the fuel rises in the tube, it is sprayed out of the jets, and, owing to the minuteness of the jets and the force with which the fuel emerges, the gasoline is broken up into very small particles and converted into a mist. The spiral arrangement of the jets insures each one a separate supply of air. This fuel tube is adjustable for low speeds, while the intermediate adjustment is obtained through the auxiliary air valve. The high speed adjustment is an air control in the funnel carrying the fuel tube. A strangling tube connected with the float chamber is also provided for easy starting.

Many of the so-called carburetor troubles are not really the fault of the carburetor at all. Air leaks along the path of the gas in the cylinder will upset the action of the best carburetors made. The air leaks may be caused by defective gaskets between the manifold and the cylinder, or manifold and carburetor, or by loose studs, nuts or cap screws in these connections. These air leaks destroy the quality of the mixture, and also reduce the vacuum created by the motor, so that a much smaller charge enters the cylinders. Mixture proportion may also change, due to some disarrangement of the auxiliary air valve, as by the slackening of the nuts controlling the spring. On the present day models this difficulty is overcome by locking these nuts with split pins. Another source of trouble is the stoppage of the feed line from the tank to the carburetor, due to foreign matter in the gasoline. There is a noticeable tendency this year towards the use of strainers to remove these impurities.

The general concensus of opinion among the makers of carburetors is that, for commercial car motors, the mixture should be heated by some means before entering the cylinders. There are numerous ways of accomplishing this, by water jacketing the carburetor or intake manifold, and by supplying heat from the exhaust manifold, either directly to the mixture, or by a heat jacket around the mixing chamber of the carburetor.

Carburetors are made with or without water jackets, while the hot-water supply is generally taken from the pump through a small pipe and returned to the cylinders. The flow is controlled by shut-off cocks, so that it may be shut off during the summer months, when better results are obtained without the aid of heat. Hot air from the exhaust manifold may be circulated and controlled in a like manner.

In some motors, part of the intake manifold passes through the water jacket of the cylinders, so that heat is supplied to the charge. The direct method is by connecting the main air pipe of the carburetor with a drum, placed around the exhaust manifold, so that the air is always preheated.

It is quite difficult to state which of the above methods are the best, as this is to some extent dependent upon the design of the carburetor. One method might work well on a certain carburetor and absolutely fail on another make.

Carburetors are generally bolted to flanges of the intake manifold; however, the heavy vibrations existing in commercial car operation have led some makers to provide separate brackets on the crank case of the engine to take the weight of the carburetor and to prevent the adjustments from becoming disarranged due to the vibration.

CHAPTER V

IGNITION SYSTEMS

High-tension Magnetos of Independent and Dual Types.—A considerable number of articles have been written on ignition systems, with the object of explaining the operation of the magneto and battery systems. However, the writer will attempt to cover this subject in such a way as to enable the laymen to acquaint themselves with the action of the magnetos on commercial car motors without mastering electrical theories. The subject is a broad one, and even the following may seem unnecessarily long, but it should be remembered that a magneto is a complicated instrument and any description in few words must necessarily be superficial and can be of little value.

Three Types.—For ignition purposes the magneto is at present considered the most efficient device. There are three main types of magnetos on the market. First, the low-tension magneto, with step-up coil, furnishing a jump spark. Second, the low-tension magneto in connection with the make and break system. Third, the high-tension magneto, furnishing a jump spark.

Low Tension for Jump Spark.—The first system is largely used, having the advantage of low first cost, but necessitates considerable complications and in reality is a high-tension system; as the spark is made to jump across the air gap between the spark plug electrodes, with the use of the step-up coil. The air which lies between the two electrodes is a non-conductor and is an obstacle to the flow of electrical current, so that a very high electrical pressure is needed to send a spark through it; therefore, all different methods which involve a spark plug may be called high-tension systems. The ultimate object of all ignition systems is to get a spark between two conductors located in the engine cylinders.

Low Tension for Make and Break.—The second system is very rarely used on commercial cars at present, being discarded owing to its mechanical complications and the large amount of attention required to keep it in working conditions. In this system the spark plugs are discarded and two conductors are so arranged that they actually touch each other in the cylinder. One conductor is fixed and insulated from the cylinder, while the other is arranged to be moved by a mechanical mechanism, so that a gap is created, through which the spark passes.

High Tension for Jump Spark.—The third system is now the most popular, as the high tension is produced directly in the armature winding of the magneto, without the use of a coil or other auxiliary. The wiring is also the simplest, as it consists of high-tension wires to each spark plug and a low-tension wire to the switch on the dash.

The principal difference between the high-tension and the low-tension ignition systems is, that in the high-tension system there is an incomplete circuit and a spark must be driven across an air gap; whereas, in the low-tension system an electric current already flowing in a conducting circuit is driven by its own momentum across an air gap which is suddenly formed on it.

For high-tension, what is needed is a very hot spark of high frequency, positive and of a certain length to penetrate the air space between the electrodes of the spark plugs, which is generally from 1/64 to 1/32 in.

Basis of Classification.—Magnetos are classified in two groups, according to the basic principles employed in the magnetic field to generate the initial electrical impulses. These two classes are known as the armature and conductor type.

In the former, electrical current is generated by revolving several thousand feet of fine copper wire, which is wound around a soft iron core, between the pole pieces of the magneto. As the winding rotates within its narrow confines, electrical impulses are set up within the winding.

The above types may again be divided into two classes. One is called the primary armature magneto and the other is called the compound armature type. The primary type has but a single winding in the magnetic field and generates a low voltage current. It requires an outside transformer coil to step up the current to the high potential required at the spark plug. The compound armature type incorporates a second winding, or secondary winding, also upon the armature shaft. In addition, a condensor must be incorporated in the magneto.

The inductor type consists of revolving a solid steel shaft, upon which are mounted two steel fan-shaped inductor wings, within a stationary winding in the magnetic field.

High Tension in Detail.—The high-tension magneto is not only a current generator, or a substitute for the battery, but combines all the elements of a complete ignition system except the spark plugs and the switch. It generates the current, transforms it to a high pressure and distributes the high-tension current to the cylinders.

The structural portion of the magneto consists of permanent magnets of inverted U-shape, sometimes referred to as horseshoe magnets. Two such magnets are generally used on the smaller magnetos, while four are used on the larger ones. The free ends of these magnets are termed the poles, one as the north and the other as the south pole. To these poles are secured soft iron blocks, known as pole pieces or pole shoes. The magnets and pole pieces are mounted upon a non-metallic base, while the pole pieces are bored out cylindrically to receive the armature, which is of substantially cylindrical form. This armature consists of a soft iron core of *H* section, and serves to form a bridge for the magnetic flux between the pole pieces and also to carry the winding in which the current is induced. After the core has been properly insulated, several layers of heavily insulated wire are wrapped around it. To the end of this heavy wire the beginning of a very fine silk-insulated wire is connected and the wire is wound on the core until the slot is almost filled. After the outer insulating cloth is in place, bands are put around the circumference of the armature to hold the winding in place under high armature speeds. The end plates which form the shafts are then attached.

The heavy or primary winding serves primarily to generate the current, and in connection with the fine or secondary winding, also serves to multiply the pressure or voltage to such an extent that it will produce a spark between the electrodes of the spark plug in the cylinder.

Magnetic Lines of Force.—It has been found by experiment that there is an attractive and repulsive force between magnets, and that this magnetic force pervades the surrounding space. The fact that a magnet when suspended near another magnet will take a certain direction, depending upon the relations of the poles, has led to the conception of the magnetic lines of force, which emanate from the north pole of the magnet and pass through the surrounding atmosphere to the south pole.

In a magneto the magnetic lines of force flow from the pole piece of the north pole to the pole piece of the south pole through the armature and the air gap between the armature core and the pole pieces. The space between the pole pieces is termed the magnetic field.

The magnetic lines of force which pass through the armature are variously distributed according to the position of the armature in rotation. This is true because the magnetic lines of force pass more readily through the sides of the *H* than through the wiring laid between them.

Any movement of the armature on its shaft, either in making a complete revolution or in oscillating backward and forward, must operate to deflect and distort these lines of force in such a manner as to set up powerful induced currents in the armature winding.

Induction of Electrical Impulses.—Four positions of the magneto armature are shown in Fig. 48. At *A* the magnetism is represented as passing through the soft iron core, the heads of which are in close proximity to the pole pieces and threading the armature winding.

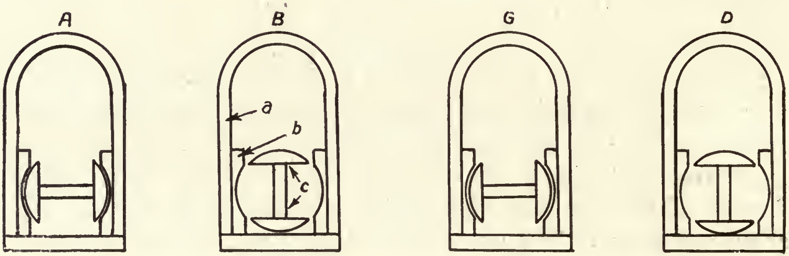

FIG. 48. Magneto Armature Positions. A, Magnet. B, Pole Piece. C, Armature.

At *B* the armature has passed to a point where its heads are just passing out of proximity of the pole pieces, and thus breaking the magnetic path between the pole pieces. At this point a sudden generation of electrical pressure is taking place in the armature winding, this causing a current to flow in it. When the armature reaches position *C* its core again forms a path for the passage of magnetism from pole piece to pole piece and the current becomes zero again. At *D* the same condition exists as in *B*, although in the opposite direction.

Thus, in each revolution two electrical impulses in opposite directions are induced in the primary winding of the armature. These impulses last only for a small fraction of the time of a revolution and are equally spaced. The electromotive force, or tension, of these is very low and entirely insufficient to cause a spark to jump between the spark plug electrodes, separated by even the shortest air gap.

Giving the Impulses Sufficient Strength.—The next step consists in transforming these impulses, or multiplying their pressure several thousand times. It is for this purpose that the fine wire winding is provided on the armature. When the armature is being rotated between the pole pieces an electromotive force is being induced in the secondary or fine wire winding, the same as in the primary or course wire winding and many times greater, but still not sufficiently great to bridge the spark plug electrodes.

The primary winding is ordinarily closed upon itself. This causes a current to flow in it more or less proportional to the electromotive force. That is, the current is at a maximum when the armature is in a vertical position. At that time there are practically no lines of force from the permanent magnets passing through the central part of the core. But the heavy current flowing in the primary winding makes of the core an electromagnet, setting up a magnetic field at right angles to that of the permanent magnets. Now, if at this moment the primary circuit be suddenly opened, the current in it will almost instantly cease flowing and the magnetism set up by this current will vanish. These lines of force are also included by the turns of the secondary winding, and as they are withdrawn so exceedingly rapidly, and since there are such a large number of turns in the secondary winding, the result is that an enormous electromotive force is induced in the secondary winding, which will cause the spark to bridge a gap in the atmosphere of from one half to three fourths inch long.

The Circuit Breaker.—A device known as the circuit breaker, or interrupter, is used to open and close the primary circuit. This is carried on the armature shaft opposite the driving end of the magneto.

It is represented in Fig. 49 and consists of a stationary contact *A* and a movable contact *B* on the arm *C*. Both of these parts are mounted on a brass disc *D*, which is securely fastened to the armature shaft and rotates with it. The stationary contact *A* is insulated from the disc *D*, while the movable contact *B* is in metallic contact with it, and the disc *D* is grounded to the frame of the magneto by a grounding brush. The circuit breaker is surrounded by a cylindrical housing *F*, to the interior of which at diametrically opposite points are secured steel cam blocks, *G–G*. Ordinarily these two contact points are kept in contact by a spring. As the disc *D* rotates, the outer end of the arm *C* comes in contact with the cam blocks *G*, whereby *A* and *B* are separated momentarily. As soon as the cam block *G* has been passed, a spring brings the two contact points together again. Stationary contact *A* is connected with one end of the primary winding of the armature, while the other end has a metallic connection with the armature core; or in other words, is grounded.

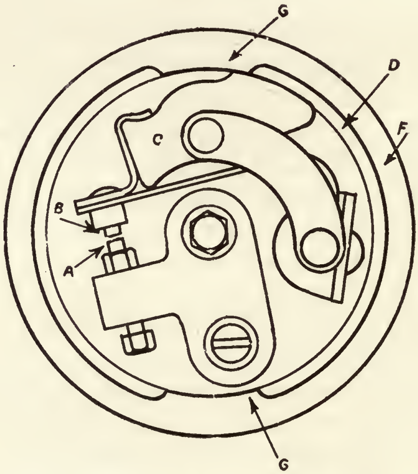

Fig. 49. Diagram of Circuit Breaker.

When these two contact points are suddenly separated, there is a tendency for the current to continue to flow across the gap, it possessing a property similar to the inertia of matter. This would result in a hot spark being formed between the two contact points, which would not only burn the points away rapidly, but would also prevent a rapid cessation of the current.

The Condenser.—To avoid this, a condenser is used, which is built into the magneto. This condenser consists of two sets of tinfoil sheets, sheets of opposite sets alternating with each other, and being separated by sheets of insulating material. All the sheets of each set are metallically connected, and one set is connected with the primary winding, while the other set is grounded. These condensers are capable of absorbing an electrical charge, and their capacity is so proportioned that they will take up the entire charge of extra current produced when the contact points of the circuit breaker separate—that is, the extra current instead of appearing in the form of a spark across the gap, passes into the condenser.

Controlling the Point of Ignition.—The magneto armature is positively driven from the motor crankshaft and the current impulse in the armature always occurs when the piston is in a certain position. Since in regular operation of the motor the charge is ignited just an instant before the completion of the compression stroke, the magneto armature is so set relative to the engine crankshaft that the maximum induction effect occurs at this moment. This construction is termed a fixed spark. However, quite a few users demand a variable spark; or in other words, to vary the time of the cycle when ignition occurs. In order to make this possible, the circuit-breaker housing *F* is so arranged that it can be rocked around its axis, being provided with a lever arm for this purpose, which is connected with the spark lever on the steering gear.

In the Mea magneto, owing to its construction, the circuit breaker and the magnets are moved around their axis so that the armature will hold its relation to the pole pieces, whether advanced or retarded.

An Automatic Control.—One model of Eiseman magneto incorporates an automatic spark advance, which is accomplished by the action of centrifugal force on a pair of weights attached to one end of a sleeve, through which runs the shaft of the magneto, and hinged at the other end of the armature. Along the armature shaft run two helicoidal ridges, which engage with similarly shaped splines in the sleeve. When the armature is rotated, the weights begin to spread and exert a longitudinal pull on the sleeve, which in turn changes the position of the armature with reference to the pole pieces. In this way the moment of the greatest induction is advanced or retarded, and with it the breaker in the primary circuit.

The Distributor.—The high-tension current is distributed to the spark plugs in the following manner: One end of the secondary winding is grounded through the primary winding, since it is attached to one end of the primary, the other end of which is grounded. The other end of the secondary generally leads to the collector ring, from which the current is taken off by a carbon brush. From here the current is carried through a spring contact conductor to a distributor on the magneto. This distributor consists of an insulated disc, in which are imbedded on the inner side one central contact piece and four or six sector-shaped contact pieces, the number depending upon the number of cylinders on the engine. This distributor also comprises a shaft which carries a gear wheel meshing with another on the armature shaft. The reduction between these gears is two to one, so that the armature shaft makes two turns. The large gear wheel carries a brush holder, containing a carbon brush, which makes contact simultaneously with the central contact piece and one of the sector-shaped contact pieces, which are connected by means of wiring or cable to the spark plugs.

A magneto must be so designed that it will give a sufficiently hot spark at a comparatively low engine speed. This ability implies the ability of generating very large and hot sparks and enormously high tensions at high engine speeds.

The Safety Gap.—The electromotive force generated in the secondary winding is limited to the size of the spark gap of the spark plugs; for, as soon as the tension reaches a point sufficient to jump this gap, the discharge occurs and there is no further increase in the electromotive force. If, by chance, the gap between the spark plug electrodes become large enough that there is no chance for the sparks to pass in the ordinary way, the electromotive force in the secondary winding might build up to such an extent as to puncture the insulation of the winding and ruin the armature. To avoid this, a safety gap is provided in which the gap is larger than in the spark plugs. Under ordinary conditions, no spark will pass between the two terminals of the safety gap. However, should the condition mentioned above arise, a discharge will occur at the safety gap, preventing the electromotive force from rising still higher.

Function of the Switch.—In order to stop the magneto from producing sparks, when it is desired to shut down the motor, a switch is provided. One terminal of the switch is grounded to the engine or frame, while the other is connected to a binding post on the circuit-breaker housing. This binder post is, in turn, connected with the contact points of the circuit breaker. When the switch is closed, the current generated in the primary winding flows to the contact points and through the binding post and connecting wire to the switch, whence it passes through a wire to the frame work of the car and return to the beginning of the primary winding. In other words, the switch cuts out the circuit breaker and the primary winding is short circuited all the time, so that the opening and closing of the contact points has no effect.

Summary of Independent System.—Fig. 50 shows the path of the primary circuit originating in the primary winding of the armature. It flows through the contact breaker screw to the stationary contact point, thence across to the movable contact point,

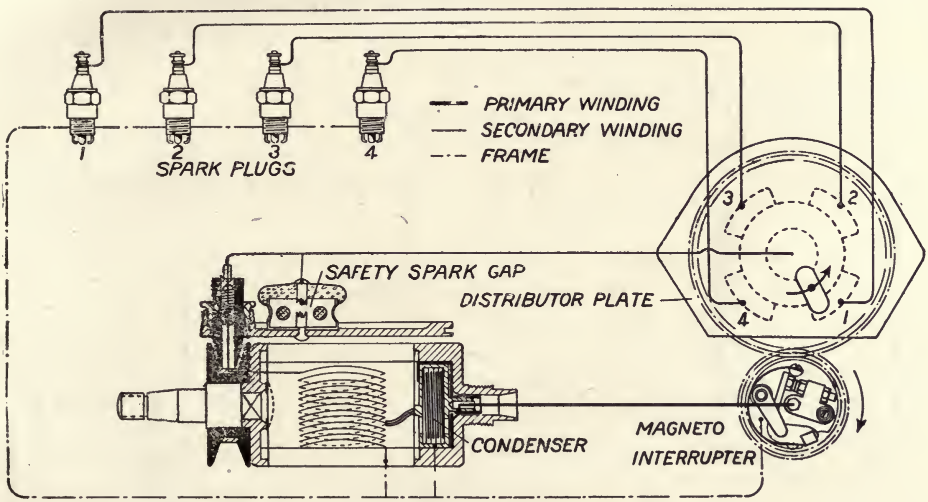

FIG. 50. Path of Primary Circuit, Originating in the Armature. Primary Winding.

from where it is led through the contact brush in the framework of the magneto, whence it returns to the beginning of the primary winding, which is also connected or grounded to the frame. The beginning of the secondary winding is connected to one end of the primary winding, and since one end of the primary is grounded, the secondary is also grounded through the primary. The other end of the secondary winding leads to the insulated collector ring, from which the current is taken off by a carbon contact brush. From the brush holder the current is carried through a spring contact conductor to the distributor, from where it is distributed to the spark plugs.

Dual Systems.—So far high-tension magnetos of the independent type have been discussed. However, most all magneto makers also build high-tension magnetos, which provide a dual ignition system, using a battery and coil with one set of spark plugs. Some makers use the magneto breaker for the battery current, while others provide a separate circuit breaker to avoid the possibility of both systems being put out of commission by an accident affecting only one, but subsequently extended to the other on account of its close relationship. The same distributor is used for both systems.

The Coil.—The battery current is of a low tension and connected with a two-point switch on the coil. From the coil the current is led to the circuit breaked, and, as the circuit is broken

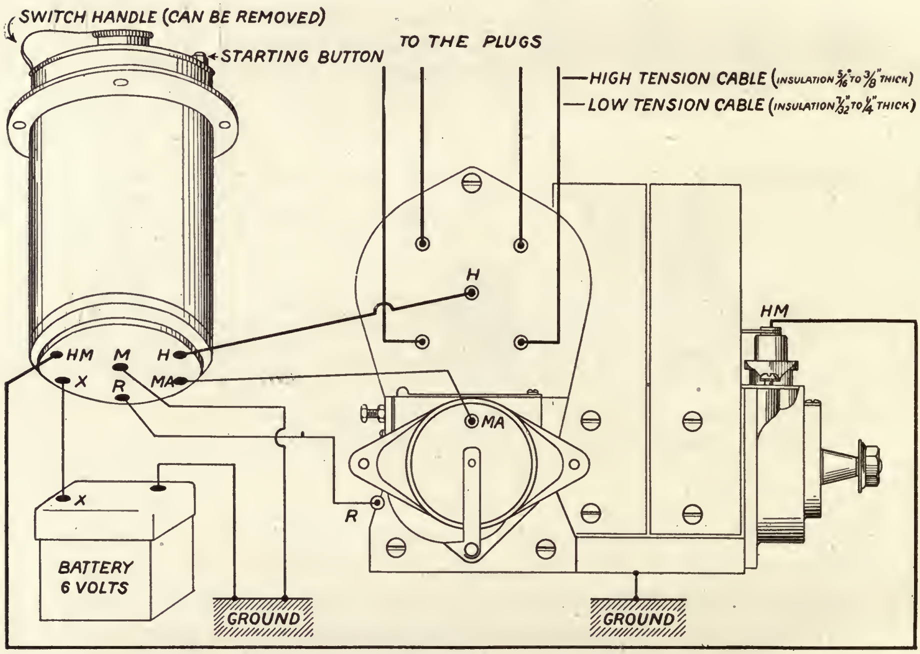

FIG. 51. Wiring. Diagram of Eiseman Dual-Ignition System.

at the proper moment, a very high voltage is induced in the secondary of the coil or transformer, and being delivered to a heavily insulated cable, is conducted to the central carbon brush of the distributor, whence it is delivered to the spark plugs in the different cylinders in correct sequence.

The coil has a primary and secondary winding, similar to that of the armature of the magneto, and performs the same function in the battery circuit, being provided with a separate condenser.

Fig. 51 is a wiring diagram of the Eiseman dual ignition system. The high tension is led from the collector ring of the magneto of *HM* and led to *HM* on the coil, thence to the switch *H* on the coil and to *H* on the magneto. When the coil handle is shoved over to the battery position, several operations take place in the switch of the coil. First, the primary current, emanating from the terminal *MA* of the magneto, is led to the ground or body of the magneto, and this prevents it from generating a high-tension current. Second, the battery current is allowed to flow in the coil at + on the coil, through the coil, thence to *R* on the coil to *R* on the magneto, where it is interrupted by a circuit breaker, thence it returns to the battery through the ground. When it is desired to stop the motor, the coil handle is moved to the off position, cutting off the battery current and the magneto current remains short circuited, thus eliminating all ignition.

Operation of Switch.—But, if instead of leaving the handle at "off," it is quickly shoved from "Bat," to "Mag," without arresting it between the two, the motor begins to run on the magneto current. In this case the battery current is left cut off as in the "off" position, while the connection, which in both the other positions has led the primary circuit of the magneto to be ground, is broken, with the result that this current is diverted to the breaker mechanism on the armature shaft, thus generating in the secondary winding of the magneto the high-tension current led to the spark plug.

The same distributor is used for the battery high-tension current, for, when the switch is on "Bat," there is a connection made between the end of the coil's secondary winding and the terminal *H* on the coil, which sends the battery current over the same route as that of the magneto.

Before the motor is in motion, the interrupter *R*, still referring to Fig. 51, cannot operate, and this makes necessary interruptions by hand with a starter knob when starting from the seat on compression. This takes the place momentarily of the circuit breaker, being supplanted by the latter the moment the engine turns over.

Low-tension Magneto and Battery Systems.—As mentioned in the above, all systems using a spark plug are termed high-tension systems; however, a low-tension magneto may be used with a transformer coil. Reference was made to the instrument having a single winding on its armature and employing a step-up coil with a primary and secondary winding. This type, termed a high-tension system, although a low-tension current is obtained from the instrument itself. However, this low-tension current is transformed into a high-tension by the coil.

These coils are similar to those used in connection with battery systems, and as but few more wires are necessary to use a battery current, the system is generally of the dual type, making use of the magneto interrupter and distributor for both magneto and battery current. The low-tension magneto is sometimes defined as the primary armature type, as it incorporates but a single or primary winding in the magnetic field.

The construction of a low-tension magneto is similar to that of the high-tension type. It consists of permanent magnets of inverted U-shape, and the pole pieces bored out cylindrically, mounted upon a non-metallic base. The armature is also of *H* section, carries a primary winding and serves to form a bridge for the magnetic flux between the pole pieces. The armature core is wrapped with primary wire until the slot is almost filled. The insulating cloth is then put in place and the armature banded.

A low-voltage current is furnished by the magneto armature to the primary winding of the coil, while a secondary winding in the coil transforms this to a high voltage.

The interrupter and distributor are similar to the high-tension type and perform the same functions in the system.

The main constructive difference between the low and high-tension types is that the former has but one winding on the armature, using a transformer coil to raise current pressure value, whereas the high-tension type has a secondary winding incorporated in the armature.

The principle of a rotating armature and the method of generating current in the magnetic field was explained previously. We may now discuss the method of transforming the low-tension current to a high tension.

Fig. 52 is a wiring diagram of this type, with external transformer coil. It will be noted that the primary winding of the transformer is so connected with the magneto armature winding that it completes the metallic circuit through the latter. That is, the transformer primary is in series with the armature winding. The breaker points are separated at definite intervals, and are so connected into the armature and transformer primary circuit that a direct short circuit through the armature winding is caused when they are in contact. The breaker points are here said to be connected in parallel with the transformer primary.

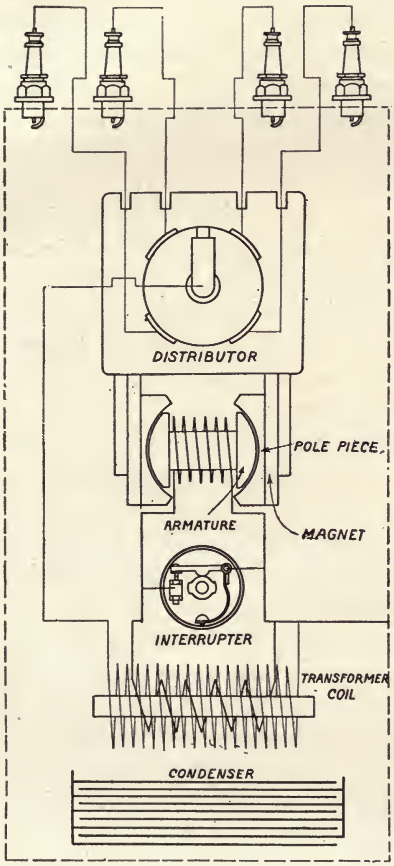

Fig. 52. Wiring Diagram for Low-Tension Magneto with External Transformer Coil.

As the induced electric pressure within the armature winding rises in value, due to the motion of the armature in the magnetic field, it flows through the circuit formed by the armature winding and the circuit breaker points until the instant at which it has attained its maximum value, when the contact points are separated and the direct short circuit broken. When this separation of the points occurs, the induced electric pressure is caused to enter the transformer primary with great suddenness and create lines of force through the transformer windings with extreme rapidity. This entry by the current and consequent creation of lines of force causes the lines to cut the secondary winding during the formation of the magnetic field about the transformer, and this cutting induces an electrical pressure within the secondary.

Of course with this system the armature of the magneto is positively driven from the engine by gears, so that the points of maximum pressure induction in the armature winding may coincide with the instants at which ignition sparks are desired within the engine cylinders. Such a single transformer with a single breaker is employed and all the current for ignition is generated therein; it is necessary that some means be fitted for the distribution and consecutive connections of the transformer secondary with the proper spark plugs in the cylinders. This distribution is accomplished by a distributor, also made an integral part of the magneto, and driven positively and in a definite relationship with the circuit breaker as in the high-tension type.

Again referring to Fig. 52, it is seen that the ends of the transformer secondary winding are connected, for the completion of its circuit through the spark plugs, one to engine frame, or in other words, one end is grounded and the other the central carbon brush holder of the distributor.

This distributor is of the same construction as in the high-tension system, so that the high-tension current induced in the secondary winding will be forced to follow the path selected for it, depending upon the position of the carbon brush of the distributor. In this illustration the heavy lines illustrate the primary circuit and the light lines the secondary circuit.

Most coils in use at the present writing are of the non-vibrating type, the trembler type of box coil having been discarded long ago, and the interrupter is now operated mechanically instead of electrically.

These non-vibrating or transformer coils, as they are termed, are made in various styles, and sometimes incorporate the switch and a push button for starting on the spark.

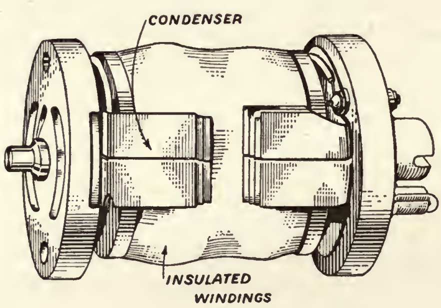

Fig. 53. Transformer Coil.

The most popular type is the tube coil with switch, which can be mounted on the dash under the hood with switch on the outside, within reach of the operator. In some cases the coil is made separately and mounted under the hood, while the switch has the usual position on the dash.

Fig. 53 illustrates the wound core of a transformer coil, complete with condenser casing. These coils are mounted in a tubular case provided with front and rear end plates. The front plate carries the switch handle and push button, while the rear end carries the terminals and is enclosed by a cover, so that the coil and connections are thoroughly protected.

The push button is used for producing a spark in the cylinder by interrupting the primary circuit leading from the battery, taking the place momentarily of the breaker on the magneto. Some coils are fitted with a ratchet mechanism giving a series of sparks in the cylinder. Some are also provided with a lock and key, so that the switch may be locked in the "off" position, preventing the unauthorized use of the truck.

The action of the switch was explained previously in connection with the dual system, and requires no further discussion.

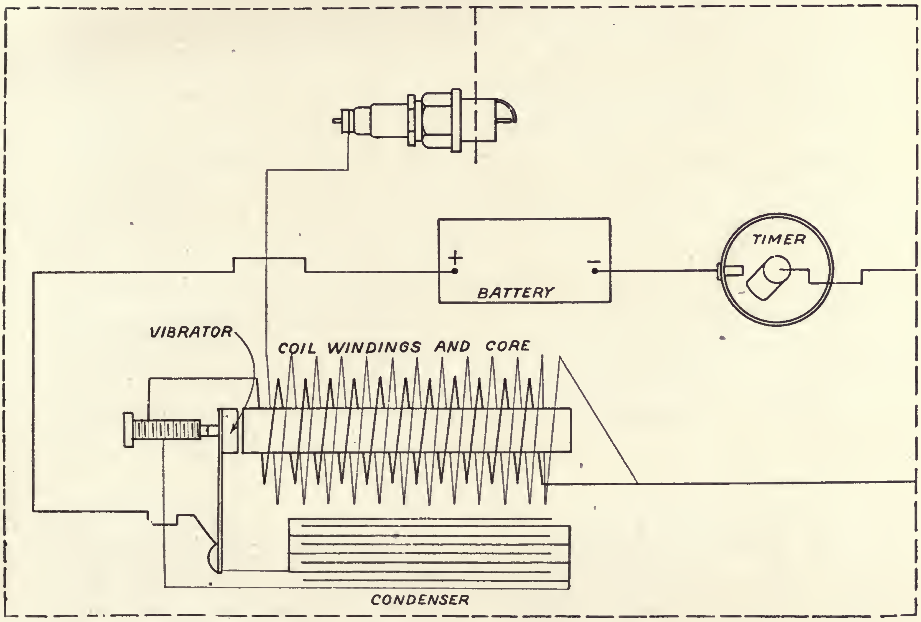

Fig. 54. Wiring Diagram of an Induction Coil and the Other Components of a Battery System.

The battery system, providing a jump spark, was extensively used before the magneto became so popular. This system requires a series of dry cells or a storage battery, affording a low-tension current and a timer, the current being stepped-up to a high-tension by induction. The principle of self-induction is as follows:

A current flowing through a coil of wire will set up a magnetic field in the surrounding space, but when the current is stopped the magnetic field will stop. The effect of the stoppage of the flow of current in this coil is the same as that due to the change of position of the wire coil in a magnetic field, so that when the current is stopped there will be a current induced in the coil. The result is that when the circuit is broken to stop the current, the decrease in the current adds momentarily to the electromotive action in the circuit and a visible spark, or even an arc, is formed at the break.

Fig. 54 makes clear the principles of an induction coil, showing the primary and secondary circuits and the other components of the system.

The primary and secondary windings are identical with those of the compound armature, or high-tension magneto, the former consisting of a small number of turns of coarse insulated wire, while the latter is a very fine silk insulated wire, and the number of turns greatly exceeds those of the primary winding. In this system no mechanically operated interrupter is used for breaking the primary circuit, this being accomplished by a device for automatically and rapidly making and breaking the circuit.

The device is known as a vibrator or trembler, as it is sometimes termed, and consists of an iron disc of approximately the same diameter as the core of the coil, attached to flat spring and a platinum point located above the disc. An adjusting screw mounted above the disc carries another platinum point. These points are so situated on the coil that they make contact with each other. When these two points are in contact, the primary circuit is closed.

The automatic action of this vibrator is as follows: The current flowing through the primary circuit of the coil makes an electromagnet of the core, which attracts the iron disc attached to the vibrator spring, causing the points to separate. As the current is interrupted by the separation of these points, the core ceases to be an electromagnet, since no current is flowing through it and the disc is no longer attracted permitting the points to make contact and again complete the primary circuit. This action continues as long as the current flows and is interrupted in the primary circuit. By varying the adjustment of the adjusting screws the number of sparks in a given time are varied, as is also the strength of the individual sparks.

To prevent prolonging the magnetization of the core beyond the desired limit, a condenser is connected with the contact points to absorb the surplus current induced in the primary circuit, due to the breaking of the circuit. In other words, when the points are in contact, the condenser is short circuited, but when the circuit is broken the induced current, instead of jumping across the gap, passes into the condenser, and as the circuit is again completed it passes out again and into the circuit. A commutator, or timer, is used to determine the exact time in the cycle of the engine at which ignition occurs.

The diagram shown herewith represents a single-cylinder system, while multi-cylinder engines require a coil for each cylinder, but the battery current passing into the primary winding of the coils is controlled by a single switch. The coil units are incorporated in a box or housing which is mounted on the dash board, with a removable cover, so that any coil may be adjusted. As each coil is a separate unit, they may be so constructed that they may easily be replaced should they become defective, without disturbing any connections.

In every high-tension battery system a device is required for opening and closing the primary circuit at the proper instant, with respect to the cycle of the engine, and the position of the piston in the cylinder. This device is known as the timer, because it determines the exact time in the cycle of the engine at which ignition occurs and permits of varying this point at will while the engine is in operation. It is positively driven by gears from the motor either direct or through an auxiliary shaft from the cam shaft. This timer (Fig. 55) consists of a housing containing a roller and arm members so mounted upon the driving shaft that the roller and arm members may rotate, while the housing is held stationary by means of a rod or lever, which may be moved in either direction to advance or retard the spark. Within the housing is a fiber ring in which are mounted metal contact segments, the surfaces of which are flush with the fiber.

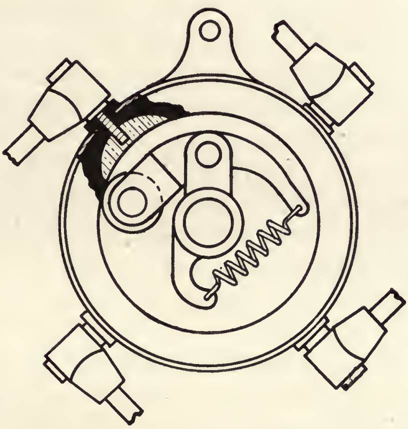

Fig. 55. Timer for Battery System.

These segments are held in position by screw bolts which pass through the fiber ring and housing, but are insulated from the latter. These screw bolts are provided with thumb nuts and terminals to which is secured a primary wire, which in turn is connected to the primary terminal of the induction coil.

The operation of the timer is as follows: The shaft actuating the roller is metal, and one lead from the battery is connected to the frame, or other metal part, and the current is conducted from its source to the metal segment. As the roller makes contact with the segment in the fiber ring, the circuit is closed and the current flows through the roller frame and primary wire back to its original source. As the roller contact with the segment is broken, the primary current in the coil is established and broken as previously described, being built up in the secondary winding, and a spark produced at the gap of the spark plug electrodes.

The vibrator coil system has its disadvantages, having several primary contacts, sliding or rolling contacts in the timer, and a delicate, magnetic interrupter. To overcome these faults, igniters were introduced which combine a mechanical interrupter with a high-tension distributor. The induction coil is replaced by a transformer coil, as used with the primary armature type of magneto. With the igniter system but one primary contact is necessary and the circuit is made and broken positively by mechanical means.

The contact points are generally so constructed that they may be adjusted from the outside without dismantling the unit.

Directly above the contact maker is located the high-tension distributor. Its construction is similar to the high-tension magneto distributor, using a central contact brush and segments located radially which are connected with the spark plugs of the motor.

The advantages of this system over the vibrator coil system are two-fold. As there is only one set of wearing parts, whatever wear occurs will affect the timing of all cylinders equally and subsequently a perfect relationship is maintained at all times. Again the character of the spark in all cylinders must be identical.

Fig. 56 indicates the path of the current in the igniter system, passing from the battery to the switch on the coil, thence to the interrupter, from where it is led to the coil and stepped-up to a high pressure. From the coil it passes through a conductor to the central contact of the distributor and is distributed to the cylinders in proper sequence.

Either the vibrator and timer system, or the igniter system, may be used in connection with either the primary or compound armature magneto, thus forming two separate systems of ignition, with either one or two sets of spark plugs. With the former type the magneto distributor is used for both systems, while a vibrator and a transformer coil are mounted together and controlled by a single switch. When the compound armature magneto is used, but one coil is necessary for the battery system. The above is also true of the igniter and transformed coil, excepting, of course, that but one coil is necessary for either type of magneto.

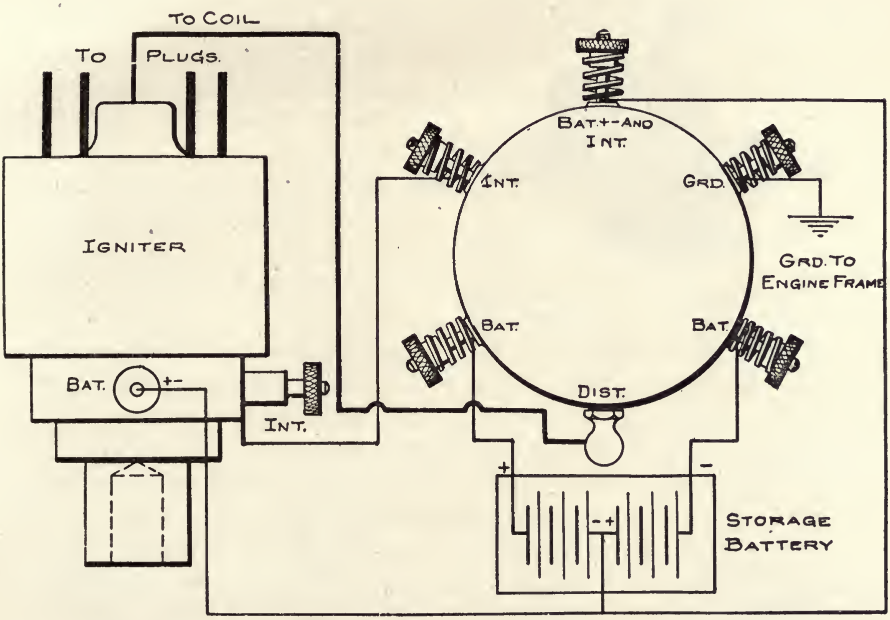

Fig. 56. Indicating the Path of Current in an Igniter System.

Inductor Magnetos.—The magnetos described previously, generating either high or low-tension current, were built on the principle of placing the winding or windings on the armature core, so as to rotate in unison with the armature.

The inductor type of magneto differs from the above, in that the windings are stationary within the magnetic field of the magneto and the armature is replaced by inductors which revolve, being attached to a shaft. In fact, these are the distinguishing features of this type of magneto. In other words, a stationary winding is used and mechanical energy is transformed into electrical energy through a distinctive principle known as induction.

This inductor type, like the primary and compound armature types, consists of permanent inverted U-magnets and pole pieces which form the magnetic field, mounted upon a non-metallic base. The winding or windings may be arranged for either a high or low-tension current and may either be placed in the magnetic field or at the rear end of the magneto.

The armature is replaced by inductors, mounted upon a shaft, this unit being termed the rotor shaft. The inductors are in some cases fan-shaped. The Remy inductor shaft, which is of this type, is illustrated in Fig. 57. It is made of laminated steel, claim being made for a better magnetic circuit with this construction. Each lamination is given an insulated coating on one side, the object of this being to eliminate eddy currents and to reduce heat losses.

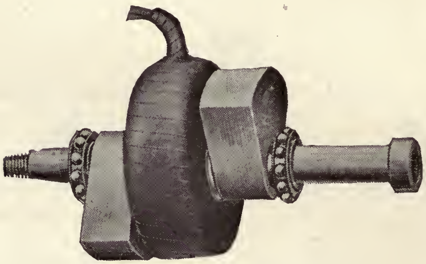

Fig. 57. Remy Induction Shaft.

The circuit breaker, or interrupter, is also used to open and close the primary circuit at the proper time, while the distributor is also resorted to to distribute the high-tension current to the proper cylinders. In fact, this type of magneto incorporates all the principal parts mentioned in connection with the previous types, such as the condenser, safety spark gap and switch.

The functions performed by these units are identical with those described previously. As mentioned above, the principal difference of this instrument over the others, lies in the method of generating the current.

Previously the method of magnetizing a bar was described in connection with the induction coil, and we may now investigate the method of utilizing this magnetism to produce electrical currents.

In a coil, an electrical current will be said to be flowing in the coil, meaning that it passes in the wire. Magnetic flux, however, will be said to pass through the core in either direction, the core serving as a path to direct the magnetism through the coil. An electrical action is produced by the action of the magnetism in the core only when the strength of the magnetism varies, that is, when it increases or decreases. When this is the case an electromotive force is induced in the winding and, the more rapid the variation of the magnetism, the greater the induced electromotive force. Even if the core is traversed by a large amount of magnetism, it has no effect on the winding, as long as its value is unchanged. Electromotive force tends to produce an electric current and if the circuit is closed it actually does produce a current.

The electromotive force produced in a single turn of winding is proportional to the rate at which the magnetism through that turn varies. A winding of several turns may be regarded as several windings of one turn, connected in series, so that to obtain a high induced electromotive force, a winding of several turns is used, just as several dry cells are connected in series to obtain a higher electromotive force from that obtained from a single cell.

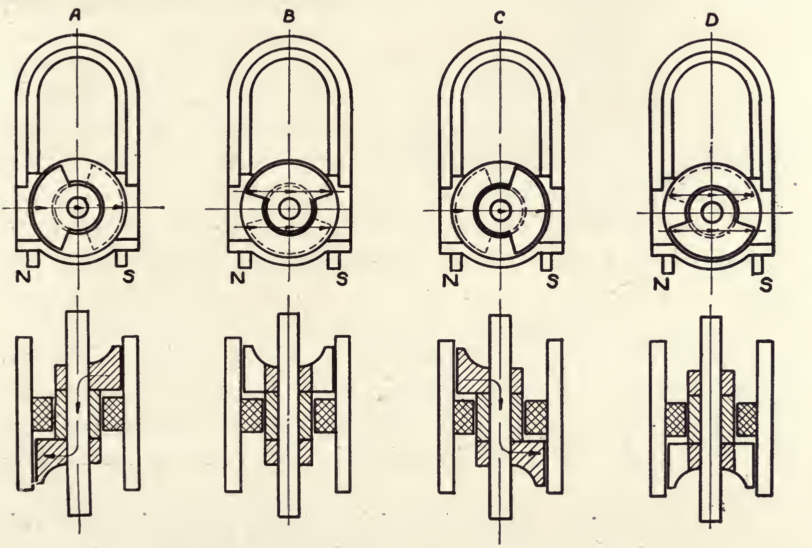

FIG. 58. Positions of Inductors and their Shaft.

In Fig. 58 are shown various positions of the inductors and their shaft. The upper view depicts the magneto with end plates removed, and the lower view represents a section of the upper view.

The stationary winding is securely held in place by the pressure of the pole pieces against it and by brass strips which have been omitted to simplify the illustration. The rear inductor, which is located to the rear of the winding, is indicated by dotted lines in the upper views. The inductors and core are secured to the shaft and rotate with it, constituting the only moving parts shown.

In order to form a path for the magnetic flux it is merely necessary to have a mass of iron joining the pole pieces, this being provided by the inductors, core and their shaft. The arrows show the path of the magnetism through the revolving parts.

In the position *A*, the front inductor is adjacent to the pole piece *N*, the rear inductor is adjacent to the pole piece *S*, and the path is formed by the inductor shaft. When the cross-section of the inductor shaft is not great enough to carry all the flux, a core must be added to carry part of it. The magnetism, therefore, in position *A*, passes from the pole piece *N*, to the front inductor, through the core and shaft to the rear inductor, thence to the pole piece *S*. The magnetism through the winding is from the front to the back.

At *B*, the inductors are so located that each forms a path between pole pieces *N* and *S*, and the magnetism passes between the pole pieces without any of it passing through the winding.

At *C*, the conditions are similar to those at *A*, but the front inductor is adjacent to the pole piece *S* and the rear one adjacent to the pole piece *N*, causing the magnetism to pass through the winding from back to front, which is opposite to the direction which it had in position *A*.

Position *D* is similar to *B*, except that the front inductor is downward and the rear inductor upward. In this position no magnetism passes through the winding. From the above it can be seen that the magnetism passing through the winding is continually varying, thereby inducing in the winding an electromotive force.

As the inductors approach position *A*, the magnetism through the winding is increasing and as they leave that position the magnetism begins to decrease, without changing its direction. The direction of the induced electromotive force is reversed as the inductors pass through position *A*, and is again reversed when they pass through position *C*. As the inductors approach position *B*, the magnetism through the winding is from front to back and decreasing, but after they have passed this position, it is from back to front and increasing, resulting in no reversal of the electromotive force. This is also true of position *D*.

Although the current from an inductor magneto may be utilized in the same manner as that from any other alternating current magneto, the above sets forth the conditions existing in the Remy magneto. This instrument generates a low-tension current and requires an outside coil to step up the current to the high potential required at the spark plugs.

In the K.W. inductor type of magneto (Figs. 59 and 60) there are four inductors as illustrated made of soft iron laminations. Two of these inductors are placed 180 degrees to each other and the other two in a plane at right angles.

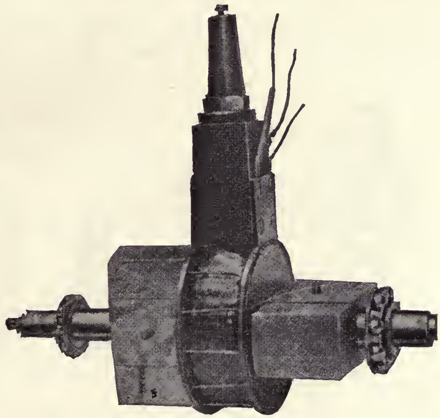

Fig. 59. K.W. Inductor Shaft.

The windings, which are concentric with the inductor shafts are mounted between the inductors and stand absolutely still. The inductors collect the magnetism from one pole piece and conduct it through the center of the windings to the opposite pole piece. The primary winding is surrounded by the secondary winding. The primary current passes through the circuit breaker and at the moment of interruption a powerful surge of current is generated in the secondary winding, which is distributed to the spark plugs, thus producing a high-tension current without the aid of external coils. This is one type of inductor magneto generating a high-tension current. The Pittsfield magneto (Fig. 61) offers another example of a high-tension inductor type magneto; however, it differs materially from the above. The usual primary and secondary windings are used, however, they are not incorporated with the inductor shaft, but are located at the rear of the magneto.

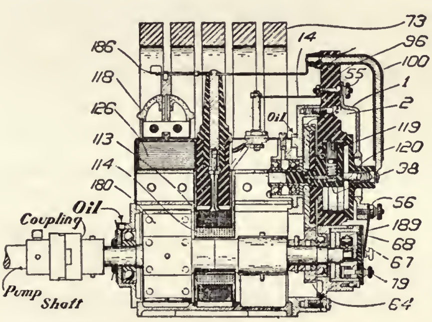

Fig. 60. K.W. High-Tension Inductor Magneto.

The three illustrations show a longitudinal section through the entire instrument, cross section through the magneto and pole pieces and end view of the interrupter.

The magnetic field contains four poles, two (*4A*) of which are the poles of the permanent magnet as illustrated, the other two poles (*4*) and the iron core (*5*) of the coil compose the field. The rotation of the inductor shaft (*1*) generates in the windings of the coil (*6*) an alternating current which attains a maximum four times during each revolution of the inductor shaft, which means, that for each 90 degrees rotation of the inductor shaft, ignition may be obtained. One end of the primary winding is

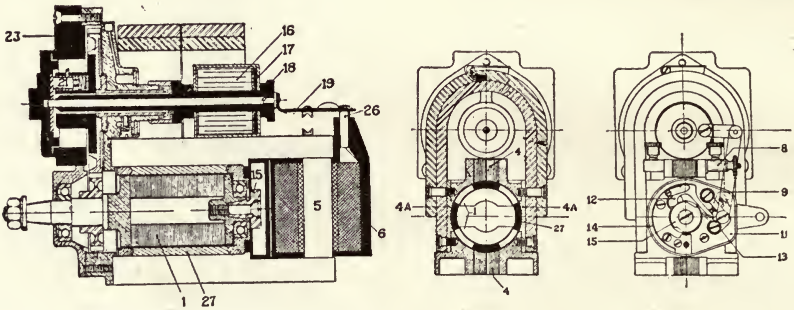

FIG. 61. Longitudinal Sectional, Cross-Section and End Views of Pittsfield Magneto.

connected to the field by a contact (*8*) and its other end is attached to a contact block (*9*) which is screwed on the field and insulated by a hard rubber bushing and plate. Connection from this plate to platinum contact block (*9*) and screw is made by a brass contact strip. The latter is insulated from the interrupter plate (*11*), which is in metallic connection with the field or ground.

The platinum screw (*13*) on the interrupter lever (*12*) is held against the platinum screw (*1*) in the insulated block by means of a spring (*14*). The current generated in the primary winding is therefore short circuited as long as the two platinum screws are in contact.

The primary current is interrupted when the core (*15*) actuates the lever (*12*) separating the platinum points. A condenser (*16*) protected by a housing (*17*) is connected in parallel to the interruption of the platinum points. One end of the secondary winding is connected to one end of the primary winding and the other is led to a conductor by means of a metal bridge (*19*). The secondary current is led from this bridge member to the distributor (*23*) by means of insulated conductors (*18*), which are connected by means of a carbon brush and spring. In the distributor plate (*23*) are socket inserts connected to distributing inserts which take the high-tension current from the revolving conductor (*21*) in proper rotation and from socket inserts in the distributor plate (*23*) cables are connected to the spark plugs in the cylinders.

The safety spark gap consists of a short pointed brass rod set on the metal bridge (*19*) connecting the high-tension terminal (*26*) on the coil (*6*) with the high-tension conductor bar (*18*), and should there be any interference with the circuit normally provided through the spark plugs, the safety gap provides a point of discharge.

The timing of the spark is generally accomplished by opening the interrupter earlier or later, and with the unavoidable result that if the position of the pole pieces in the magnetic field remains stationary, the relative position of inductor shaft and field at the moment of the break must vary. The quality of the spark, or, in other words, the heat value, depends among other factors upon the particular position of the inductors in relation to the field poles at the moment the spark is produced.

The changing of the timing is effected in the Pittsfield magneto in a unique way. The results obtained are ideal in that the same efficient spark is obtained, when the spark is either advanced, retarded or in any intermediate position. This is accomplished by means of a four-segment sleeve (no. 27), one for each pole of the machine, which sleeve is fitted with a lever with which the sleeve, with interrupter, can be advanced or retarded, giving early or late ignition.

The inductor type of magneto is also made in the dual type; in fact, in the Remy, the same transformer coil, interrupter and distributor as is used for the magneto current. With the K.W. it is necessary to employ an external coil.

The Pittsfield dual system is somewhat different from the other types explained, and owing to the unique construction it is very simple. It does away with the high-tension coil and wires from the magneto to the switch, the dual system being self-contained.

The design and constructional details of the dual machine differ from the independent type, as previously described, by insulating both ends of the primary circuit instead of one end. One end of the primary winding is connected to the interrupter as in the independent type, the other to the lever of a specially constructed switch, so that when the switch lever is on the side marked "Magneto," this primary lead is grounded, allowing the magneto to run as a straight high-tension machine. When the lever is thrown to the battery side of the switch the primary lead is then connected to the batteries, thus permitting the primary and secondary windings of the magneto to be used for either current.

CHAPTER VI

GOVERNORS AND SPEED-CONTROLLING DEVICES

Commercial car manufacturers and users are aware of the attendant results of high speeds and heavy loads over rough roads, so that at the present time this subject should be of considerable interest to those operating commercial cars.

The most practical means of obviating this excessive speed seems to be through the use of a governor, which should be sealed so that it cannot be tampered with.

This governor consists of a mechanical speed-measuring device so connected to the engine throttle as to cut off the intake when the speed exceeds a predetermined maximum. It was originally inherited from steam engine practice. However, lately, considerable improvements have been made in this device so as to make it more adaptable and efficient.

There are four methods of regulating the speed of the motor, as follows: (1) By holding the exhaust valve open or the intake closed, (2) by the spark, (3) by changing the quality of the mixture entering the cylinder, (4) by changing the quantity of the mixture entering the cylinder.

The method of regulating the motor speed through connecting the governor to the exhaust valves in such a way that these valves may be held open, and thereby retard the speed of the motors, or by connecting to the intake valves in such a way that they may be held closed, has been discarded long ago.

The Dedion Bouton method of regulating the motor speed through connecting the governor in such a way that it will open and close the electrical circuit, has also been discarded. This also applies to the method of changing the quality of the mixture entering the cylinders.

One method of governing the speed of the motor is by connecting the governor to a butterfly valve in the intake manifold, which reduces the quantity of the mixture entering the cylinder but does not in any way reduce the quality. The butterfly valve merely changes the volume of gas and allows the motor to get the proper mixture under any speed up to the setting of the governor.

The revolving ball, or more properly the centrifugal principle, is that generally employed. There are many variations of this construction and few that operate on different principles, but all are alike in fundamentals.

The hydraulic principle is also used by some. In this type, as the motor speed raises the pressure against a diaphragm connected with a plunger-head acting on the throttle spring. This action overcomes the resistance of the spring and closes the throttle. This type may either be built in a unit with the pump or connected to it.

There is also the automatic type which regulates the motor speed by governing the velocity of the incoming gases.

There are two methods of drive for the centrifugal type of governor. The usual method is direct from the engine, either through an auxiliary shaft, or by building the governor into the cam-shaft gear. With this method the speed of the governor is always proportioned to the speed of the motor.

Lately governors are being introduced which are driven from some part of the chassis and whose speed is proportioned to the speed of the vehicle instead of the motor.

In the former case the governor acts only on the motor and converts it into practically a constant speed motor. In changing speeds the allowed speed of the motor is in no wise altered.

The governor is generaly set at a maximum speed corresponding to the maximum car speed at which the car is to operate on high gear, and when it is running in second speed the effect of the governor on the motor does not change in any way. This second speed might correspond to 12 m.p.h., and the low speed to 6 m.p.h., thus limiting the motor speed on the lower gears, hence the power of the motor. This would be quite noticeable if the car was operated over a long stretch of bad road or in deep sand. The power output of the engine is dependent upon its speed and although it may be pulling hard on a wide open throttle, it is not developing its full power, for not enough power units are released from the fuel, owing to the limited speed. The maximum safe motor speed may be far above the speed permitted by governor for a given car speed.

These defects have caused engineers to investigate other methods of governor drives and has resulted in the introduction of a transmission jack shaft or front-wheel drive, on the theory that the speed of the motor should be governed by the speed of the car. In this way the truck can attain its maximum speed at a moderate engine speed, and with only a partly opened throttle. It also permits the motor to operate at a higher speed on the lower car speeds. In practice with the proper size motor for a certain car capacity, the gear ratio is generally such that the maximum safe motor speed is reached in second speed, so that the maximum power may be obtained when it is most necessary. The motor should not be permitted to develop its full power in high gear, as gear changes are provided to obtain increasing torque with decreasing car speed. Limiting the motor power in high speed is an advantage up to a certain point, for a truck should never be permitted to take a hill on high gear if it is necessary to retard the spark all the way.

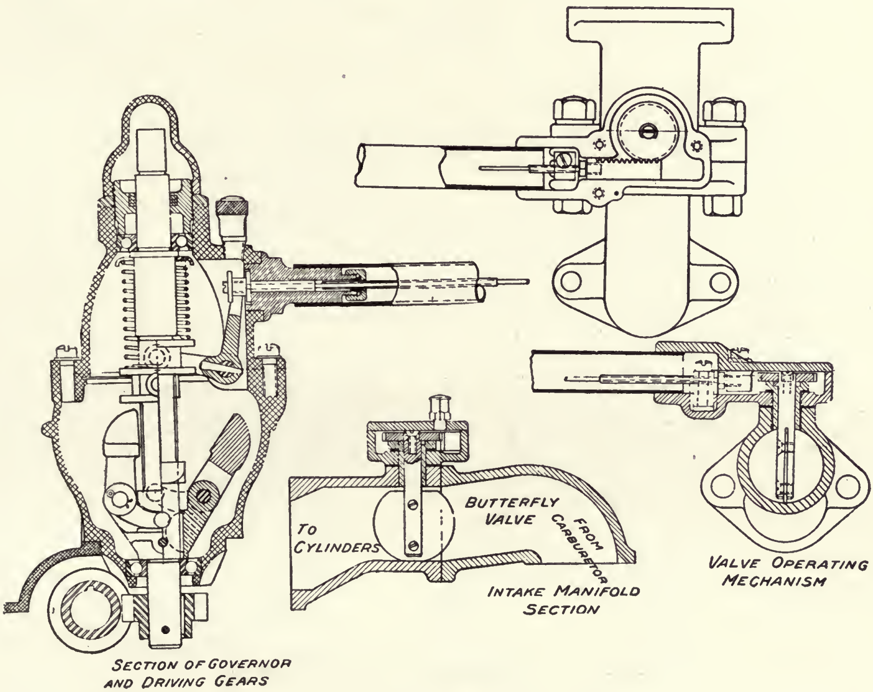

FIG. 62. Centrifugal Type of Governor.

There is also a governor on the market at the present time which controls both the motor speed and the car speed, the object of this device being to obtain a better fuel economy and to form an assistance to the driver in operating the vehicle.

While still another automatic governor in addition to controlling the speed also operates the throttle and spark and controls the motor under all speeds. The operator merely sets the governor as to the speed he wishes to make and the governor does the rest.

The writer is attempting to cover this subject in such a way as to present all types of governors now in use and those which may come into general use.

The Centrifugal Type.—Fig. 62 illustrates a centrifugal type of governor which has been used by a number of prominent com-

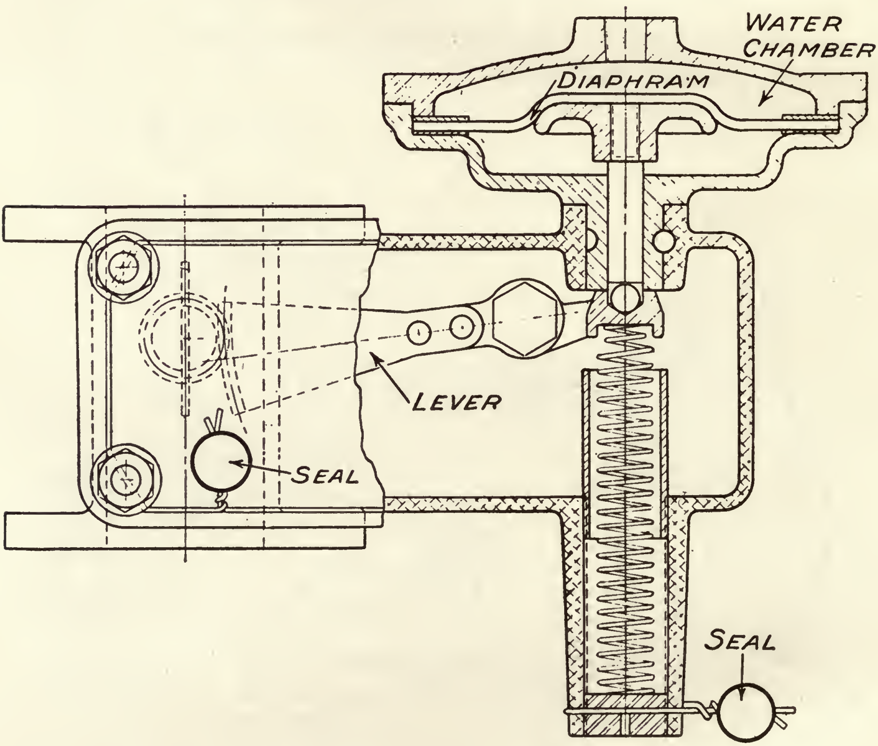

FIG. 63. Hydraulic Type of Governor.

mercial car builders. The governor is placed at the front end of the motor and is driven through spiral gears from the magneto drive shaft. As the motor speed increases the weighted levers open and raise a sleeve which operates the auxiliary throttle valve in the intake manifolds, by means of a forked lever bearing in the sleeve and a flexible shaft which operates a rack meshing with a small gear on the auxiliary valve shaft. As the speed decreases the pressure of the governor spring returns the operating parts to their neutral position.

The Hydraulic Type.—Fig. 63 shows a hydraulic type of governor used by some commercial car builders. It is mounted between the intake manifold and the carburetor. The operating mechanism is combined in a unit with the governor proper, making it a simple and compact unit. The water chamber is connected with the water pump and as the latter's speed increases, the water pressure raises and forces the diaphragm down. This diaphragm has a stem which bears on the throttle lever and is controlled by a coiled wire spring. The lever in turn forms a segment with several teeth and meshes with a small gear on the throttle valve shaft. As the pressure decreases the spring returns the diaphragm to its original setting and opens the throttle valve. The water chamber cover, operating lever housing and the spring retaining plug are sealed so that the governor cannot be tampered with, without first breaking either one of the three seals.

In both of the above types the maximum speed may be changed by increasing or decreasing the spring tension.

The Automatic Type.—An automatic type of governor is shown in Fig. 64, in which the speed is regulated by governing

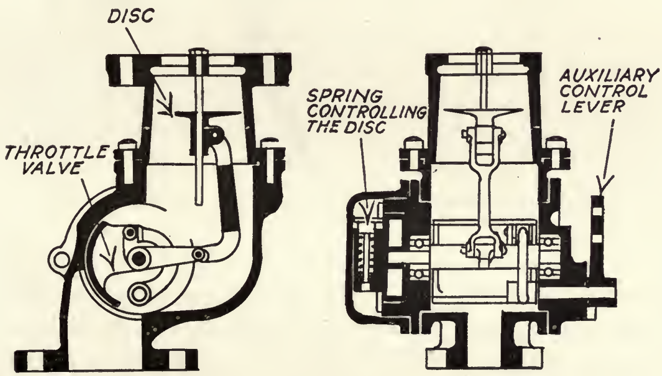

FIG. 64. Automatic-Type Governor.

the velocity of the inflowing gases. This device consists of a throttle connected to a disc that is allowed to float under a constant spring tension, in a tapered conduit, the tension of the spring determining the maximum engine speed. The slightest change in the velocity of the incoming gases caused by a difference in engine speed will affect the position of the disc in the conduit and also change the position of the throttle immediately, giving the engine more or less gas as the conditions may require. An auxiliary control lever is provided, giving the operator access to any engine speed under the maximum controlled by the governor. This governor is designed to be mounted between the intake manifold and the carburetor and does not require any form of drive whatever, its operating mechanism being self-controlled.

The Krebs truck is equipped with a centrifugal type of governor which controls the motor and car speed. The spark and throttle are so connected to the governor that it constantly sets them for the power, load and speed that may be required, without

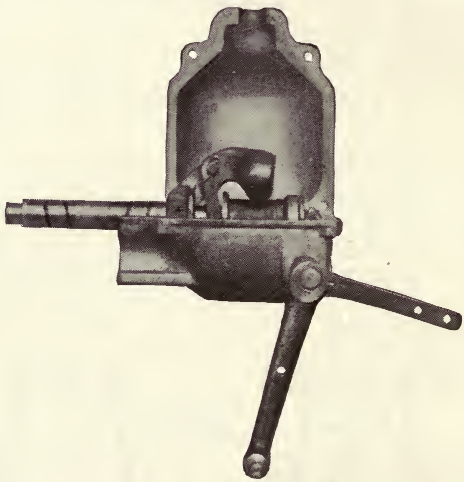

FIG. 65. Another Type of Centrifugal Governor.

regard to road conditions. The governor is also so contrived that when the clutch is disengaged, the motor continues to run at the same speed, preventing the driver from racing the engine. Engaging the clutch causes the throttle to open wide until the car reaches the speed at which the governor is set. The manufacturer of this governor claims that it takes the entire responsibility of handling the motor at all speeds and all loads. This governor is shown in Fig. 65.

Fig. 66 illustrates the Pierce engine governor, which also operates on the centrifugal principle. It differs from the above in that it is designed to be mounted between the intake manifold and the carburetor, making it more adaptable to motors in general. The drive may either be taken from the cam shaft of the motor or countershaft of the transmission. As the motor speed

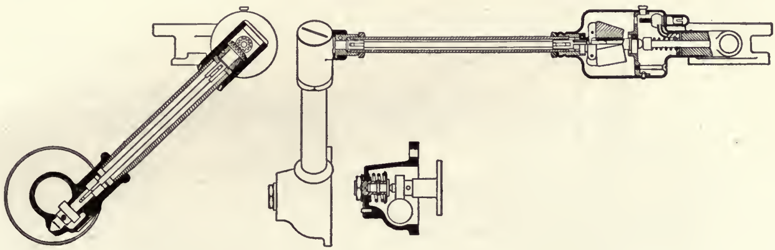

FIG. 66. Pierce Centrifugal Type Governor and Drive.

reaches the maximum setting of the governor, the triangular weights open and move endwise on the shaft upon which they are mounted, which in turn moves the operating rod. The end of this rod carries a rack gear which is in mesh with a small gear on the butterfly valve shaft. As the weights close a spring returns the rod to its neutral position. The governor also has a speed adjustment, so that any desired motor speed may be obtained. This adjustment is sealed so that it cannot be tampered with.

Fig. 67 shows the Pierce speed controller which operates on the same principles as the Pierce governor. The drive is taken from the front wheel and is similar to a speedometer drive. It is so constructed that it is impossible to remove the driving gear without breaking the seals and removing the front wheel. The triangular weights are placed at right angles to the valve operating rod, the governor shaft movement being transmitted through a bell crank. The controller is provided with a variable speed dial, which changes the spring pressure on the operating rod and permits instant adjustment of speed to suit individual requirements, automatically controlling vehicle speed, leaving the motor free at all times. This controller may also be provided with a lock so that it is impossible for any one to start the vehicle without the key.

The housing of both devices are made of aluminum, so that a minimum weight is carried by the intake manifold. The chief advantage claimed for these devices, is their adaptability to any vehicle, as it is only necessary to drop the carburetor one inch to one and one-half inches. In case of repairs it is a very simple matter to remove the governor or controller entirely, raise the carburetor and the vehicle need not be laid up pending the return of either device.

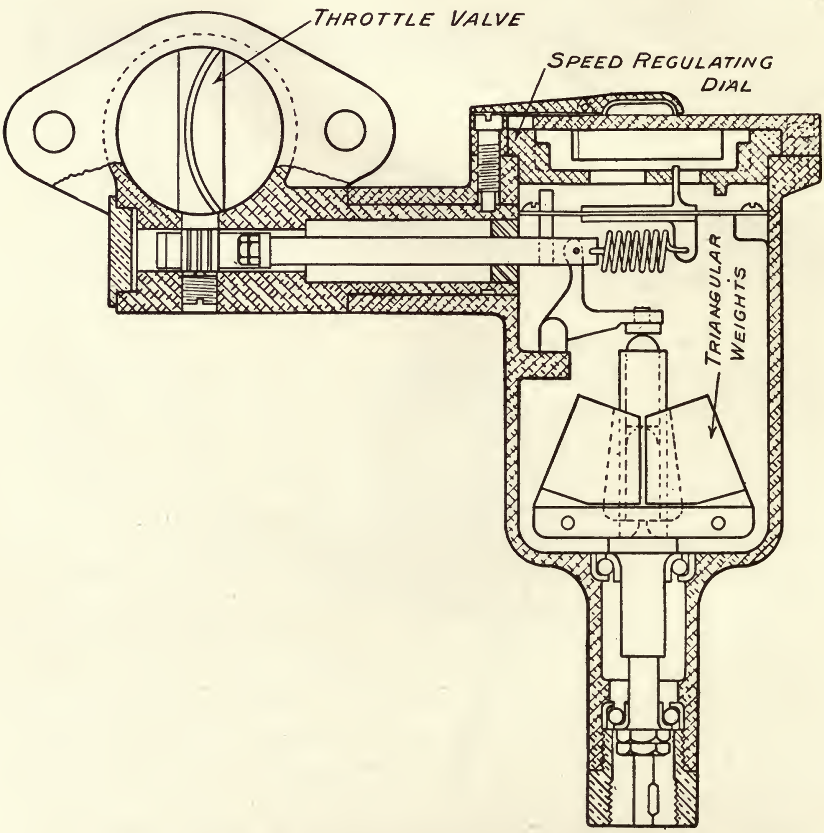

Fig. 67. Pierce Centrifugal Governor.

The Duplex governor shown in Fig. 68 was designed on the principle of a dual actuating influence. This dual influence consists of a motor influence, as to its speed, which is imparted to the governor, and a vehicle influence which is also imparted to the governor. The motor speed is conveyed from some revolving part of the motor to one of the speed terminals of the governor, and the vehicle speed from the propeller shaft or jack shaft. The conveying means consists of a steel cable revolving in a hard fiber or metallic casing. The governor is so constructed that it may be mounted between the intake manifold and the carburetor. Instead of the ordinary butterfly valve a grid valve is used, through which the entire gas supply must pass. This grid valve consists of a fixed part set into the upper part of the valve chamber, which is provided with a series of elongated slots, with flaring walls from its upper surface downward. When the openings of

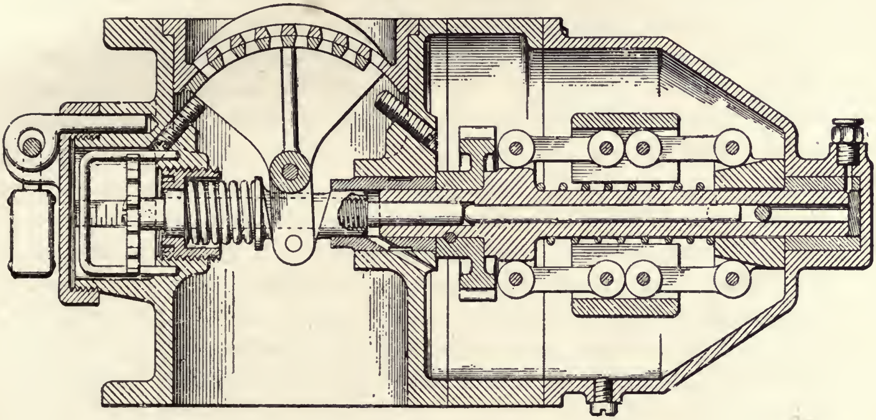

FIG. 68. The Duplex Governor.

both fixed and movable parts coincide, the valve is open and when the bars of one part cover the openings of the other part, the valve is closed. The movable part is held open by spring tension and its possible motion in either direction is limited by adjusting screws.

Within the governor there are two automatically acting one-way clutches, the floating members of which consist of gears in mesh with a third gear mounted on the centrifugal governor spindle. These clutches are so designed as to impart to the centrifugal member that of the two speeds which is the higher. With the motor running idle, the motor speed will actuate the governor, and the motor is always under governor control. When the vehicle is propelled by the motor on the higher gears, the speed imparted to the governor by the vehicle will be the higher speed and will govern the motor, whereas on the low gears the motor speed will be the higher and will govern the motor.

The influence of the centrifugal member, as a result of the speeds imparted to it, is to develop a pressure sufficient to overcome the spring pressure tending to hold the valve open, and to close it. As soon as the pressure is removed, the movable valve part is released and returned to its full open position. Provision is made for adjustment, which is enclosed and provided with a lock so that it cannot be tampered with.

These various types of governors have their advantages and disadvantages, while there may also be certain disadvantages to their omission. When commercial vehicles are not equipped with governors, the owner is forced to rely entirely upon the discretion of the operator, while the manufacturer must rely on careful management of them by the owners to prevent the evils of motor racing and excessive speed. This also applies on hills where it is asserted that governors are of no use in preventing excessive vehicle speeds.

There are some who claim that there is no adequate method yet devised which is capable of governing a truck or its engine, without handicapping the driver somewhat in the operation of the vehicle. However, the writer opines that it is worth while fool-proofing the commercial car even in a crude way, particularly in speed. With solid tires and the tendency to overload commercial vehicles, the speed becomes a large factor in obtaining long life.

It may be said that certain governing devices do limit the power of the motor on the lower car speeds. However, this may not be as serious as some think, as these vehicles are operated on the higher speed the greater portion of the time.

Some also claim that the intelligence and general ability of the commercial vehicle operator exceeds that of the touring car operator, but as the conditions of both are vastly different, it is a difficult matter to determine this fact. Truck drivers as a rule are paid a certain wage for a stipulated number of hours per week, and if they are delayed long enough in their daily trips to make their work exceed this stipulated time, they will try and make up this discrepancy by speeding up the vehicle whether loaded or empty.

However, it should be remembered that there is a certain class of conservative operators who can operate a vehicle safely without limiting its speed, but as operators of this class are few, some means must be resorted to for limiting the destruction of trucks through excessive speeding.

Many manufacturers equip their vehicles with governors admitting their shortcomings, arguing that even though the economy and efficiency of the truck may be slightly affected, this loss is more than made up for by the saving in depreciation resulting from the unskilful operation of careless drivers.

CHAPTER VII

THE CLUTCH AND TRANSMISSION

The defects in the gasoline engine, relative to its flexibility, have been previously mentioned. Among these is the inability of the motor to develop its full torque from a standstill. The crank shaft of the motor must rotate at a speed consistent with power requirements, while the road wheels must rotate consistent with road conditions, or as the operator wills. For this reason it becomes necessary to use a transmission. The motor must be started by a hand crank, or some starting device, which only produces enough torque to just turn the motor over against compression, so that it becomes necessary to disconnect the motor from the other driving units of the vehicle for starting and after the motor has attained its speed to connect it with the vehicle again.

For this purpose a device must be used, which will allow a certain amount of slippage until the motor speed has been reduced and the vehicle speed gradually accelerated to such a point that the two correspond, in this way preventing shock and jar to the driving mechanism.

This feature is accomplished by the clutch, which is most generally placed in close proximity to the motor. The most popular position is inside the flywheel. In commercial cars a single clutch is generally employed, which serves to connect the engine to the driving wheels through all of the different gear reductions. It is normally held in engagement by a single spring of large diameter, or by a number of smaller springs, and is controlled by a foot pedal to disconnect it from the motor by releasing the friction surfaces, thus disconnecting the power of the motor from the driving units. When it is desired to disconnect the engine in order to stop the car, or to change the gear, the clutch is first disengaged by foot pressure upon the pedal, which compresses the spring; the gear is then disengaged or changed and the clutch let in again.

There are quite a number of different types of clutches, all more or less extensively used, as follows: Conical clutches of the indirect or direct type, multiple disc clutches, dry plate clutches, band clutches, and combinations of cone and disc type. The construction of each type varies considerably in details of design and the materials used for the frictional surfaces.

In light commercial cars of 4,000-lbs. capacity, or under, there is a tendency to use the unit power plant, in which the motor, clutch and transmission are always held in alignment, while on the heavier types the transmission and jack shaft are combined in a unit or mounted amidships for shaft drive. With the latter types it is necessary to use a double universal joint between the clutch and transmission units. The universals take up any misalignment due to frame weaving. In some cases they are bolted to the clutch, spider or spigot, while in others they are built into the clutch center. This latter construction seems to be gaining favor with multiple disc clutches which operate in oil, a portion of which is distributed to the universal, causing it to be self-maintaining.

A variety of methods are resorted to for mounting the clutch on the spigot, plain, ball and roller bearings being used for this purpose.

There is also a tendency to provide clutch brakes so that the tendency of spinning caused by the inertia may be reduced to facilitate gear shifting.

Cone Types.—Among the conical clutches we find two types in general use, direct and indirect types. Either type consists of a male and female member, the male member being forced into the female member by the pressure of the spring or springs. When one spring is used, it is attached to the clutch spigot and when a number of small springs are used they are attached to a spider, which is free to float on the clutch spigot. The action of the clutch members is similar to a wedge movement. It is the oldest type and also the simplest type in use at present. The flywheel generally forms the female member for the direct type, while the male member may either be made from aluminum or pressed steel and covered with a material such as Raybestos, leather, etc. In the indirect type it is necessary to bolt the female member to the flywheel. The clutch spigot may either be an extension of the crank shaft or it may be bolted to the flywheel.

Fig. 69 serves to illustrate the general construction of the direct type. The male member is provided with cork inserts to obtain a higher coefficiency of friction and is bolted to a cast-steel housing, which is mounted on the clutch spigot and surrounds the clutch spring. The spigot is formed by an extension of the crank shaft, and is provided with a thrust bearing.

The cone clutch, depicted in Fig. 70, differs from the above in that three small springs are used. These small springs are supported on studs, which are riveted to the clutch spider. The spider is provided with a die-cast babbitt bearing instead of a

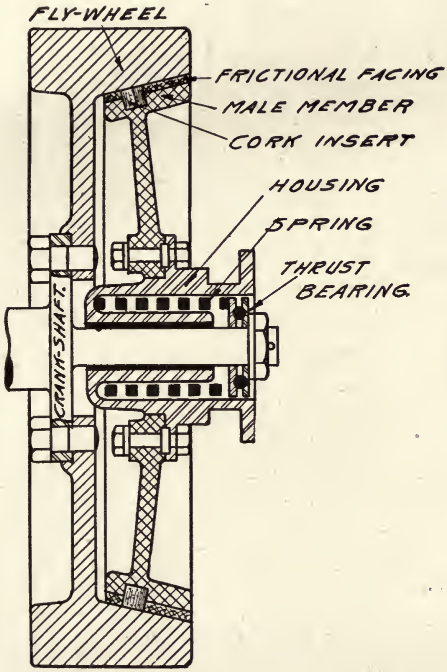

FIG. 69. General Construction of Direct Cone.

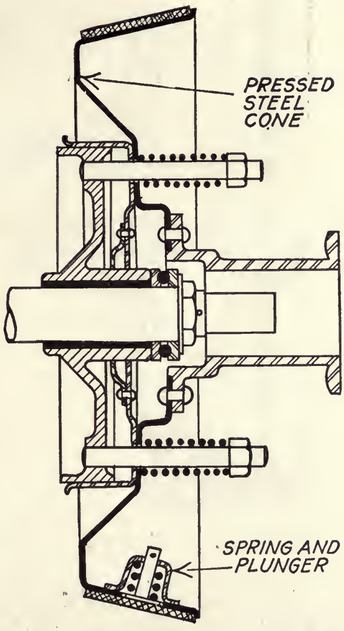

FIG. 70. Cone Clutch with Three Small Springs.

cast-bronze bearing. It depicts a type which is generally incorporated in the unit power plant, owing to its short length, which is a desirable feature.

An indirect type of cone clutch is shown in Fig. 71. The male member is made of aluminum and is provided with a frictional lining and cork inserts. Small pieces of rubber are placed under the lining to obtain a smooth and gradual engagement. The female member is made of gray iron and bolted to the flywheel. It also forms the retaining member.

The spigot is bolted to the flywheel and provided with a bronze bearing, while a roller bearing is used as a thrust bearing, and the disengaging collar is provided with a ball-thrust bearing. Cone clutches of both types are also provided with flat springs, or plungers, and coil springs, which are placed under the frictional facing, the object being to prevent the tendency to jerk when first engaged. The friction material is, in most cases, riveted to the male member, while in a few cases T-head bolts are used to facilitate its replacement, while one or two makers rivet it to the female member.

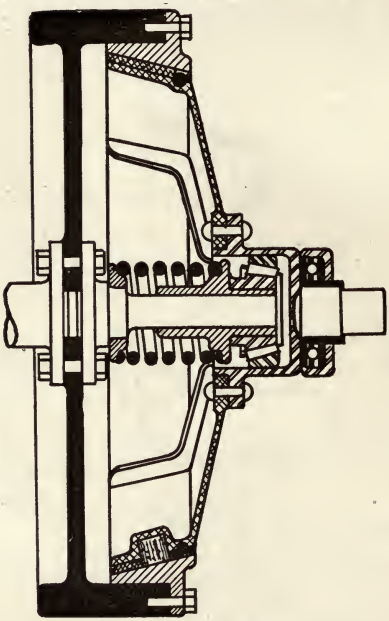

Fig. 71. Indirect Cone Type.

Multiple-disc Type.—Multiple disc and plate clutches are based on the same principle as the cone clutch, but constitute in a sense extreme opposites in design. This type offers several advantages not found in the others, being the most compact. The required frictional surface is obtained by a multiplicity of small surfaces, in preference to two large ones, as in the case of the cone and plate types.

A disc clutch consists of two sets of discs, one set being termed the driving discs and the other the driven discs. The driving discs are generally provided with key slots on their outer circumference, which fit over hardened steel keys riveted to the inside circumference of the housing bolted to the flywheel. The driven discs are also provided with key slots, but these are placed on their inner circumference, which fit over keys riveted to a housing attached to the driven shaft. It is general practice to use one more driving disc than there are driven discs, so that the two end discs may be of the same kind. The driving set is driven by the engine, while the remaining set is attached to a continuation of the transmission shaft. In some cases small flat springs are used to keep the discs apart under conditions where it is desired to render the clutch inoperative, that is, when the spring pressure is removed from them.

It is usual practice to enclose a clutch of this kind in an oil-tight case, which insures that the members will operate in a constant bath of oil, meaning long life of the frictional surface as well as gradual engagement. Owing to its comparatively small diameter, the inertia is not very great and gear shifting is somewhat easier than with the cone clutch. The spring pressure is great enough, so that when engagement is made the oil will be squeezed from between the plates and the frictional surfaces brought into contact. As the oil is gradually squeezed out, and as there will be a certain amount of slippage as long as any considerable amount of lubricant remains, the power will be applied gradually.

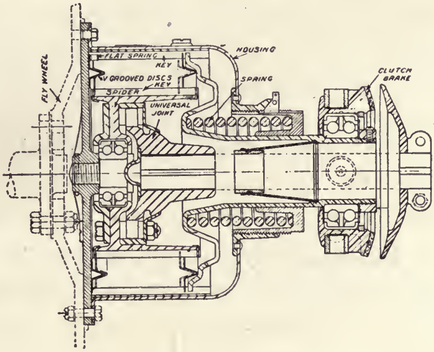

FIG. 72. Helle Shaw. Multiple-Disc Clutch. Universal Type.

A multiple-disc clutch, which is extensively used in commercial cars in this country and abroad, is the Hele-Shaw clutch, illustrated in Fig. 72. The discs are made from steel and bronze, with V-groove corrugations. Only the walls of these grooves come in contact and the remaining portions of the disc serve to radiate the heat engendered during slippage. To permit the oil to enter and escape freely, these discs have small holes drilled in the inner walls of the grooves near the peak. The action obtained by these grooves is a wedge action similar to the cone clutch. This also illustrates a design in which pressed steel is used wherever it is possible to do so. The clutch is of the universal type, having an external and internal gear type of universal, mounted inside of the clutch. A clutch brake is also provided to facilitate gear shifting, this brake being mounted upon the drive shaft and adjustable for wear.

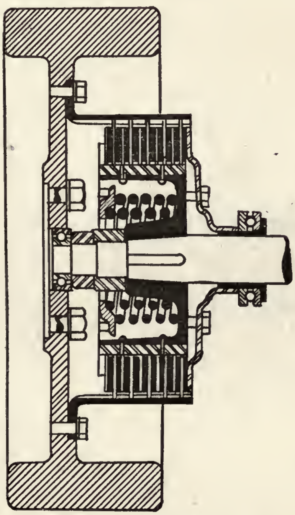

FIG. 73. Type of Multiple-Disc Clutch used in Unit Power-Plants.

Fig. 73 is a type of multiple-disc clutch used in connection with unit power plants. It is built onto an extension of the transmission shaft, one end of which is supported by a ball bearing in the flywheel. The frictional surfaces consist of saw-steel driving discs and Raybestos-line, steel-driven discs. The construction is similar to those described above, excepting that two large springs are used, one being placed around the other and retained by three bolts, which provide adjustment for the spring tension.

The housing or driving member bolted to the flywheel has teeth cut on its inner periphery into which the plates fit instead of keys and the plates have teeth instead of key slots.

Dry-plate Type.—The dry-plate clutch is similar to the multiple-disc type; however, the discs are of a much larger diameter

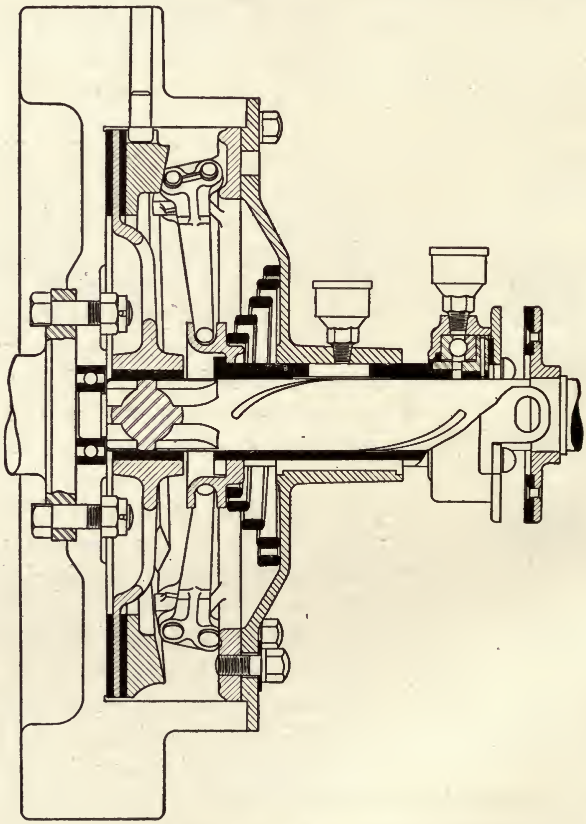

FIG. 74. Borc & Beck Dry Plate Clutch.

and but three or five plates are necessary. The driving discs are either Raybestos rings or bronze plates with cork inserts, while the driven discs are made of steel. These clutches are not designed to run in oil, but are liable to wear because of the amount of contact surface provided.

A popular three-plate clutch of conventional design is shown in Fig. 74. The face of the flywheel forms one surface, while a moving member forms the other. Between them are two discs of friction material and a floating member which is keyed to the driving shaft. Pressure is obtained by coiled spring acting on a sleeve which actuates the toggle mechanism operating the movable member. This toggle mechanism is supported by a disc which is bolted to the flange. This flange has two slots through which the bolts pass and this together with taper surfaces on the movable member form a means adjustment for wear of the friction discs.

In Fig. 81 is shown a simple plate clutch for low power delivery cars. This clutch is almost entirely of pressed steel and utilized the flywheel as a driving member. Two additional driving plates are used and these are supported by three hardened steel pins fastened to the flywheel, which also carry the springs. The driven member consists of a spur gear which supports the driven plates that have teeth cut on their inner periphery.

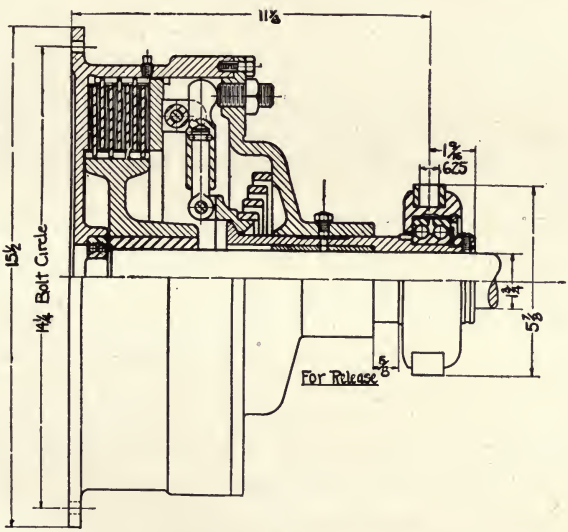

Fig. 75. Hilliard Clutch with Double Annular Ball Bearing and Enclosed Spring.

The Hilliard clutch (Fig. 75) is another excellent example of the plate type. Spinning of the rotating members is prevented by a combination of quick acting release, which does not permit of a drag while releasing and further by having the parts so light that rotation does not continue long.

Band Type.—Band clutches are practically the same in general principle of operation, as band brakes, and are of the same general types, internal expanding and external contracting. This type of clutch is not very popular, and but few can be found on commercial cars at present.

There is a tendency on the part of manufacturers to use ball bearings for supporting clutches of all types, as the plain bearing is hard to lubricate effectively and the friction of same tends to produce dragging. The ball bearing can be more easily lubricated, requires less attention and eliminates this dragging evil.

Comparisons.—The advantages of the cone clutch are that it may be engaged and disengaged with very small axial motion, axial pressure may be low because the normal pressure between frictional surfaces is multiplied by the angularity of the cone, its weight is not very great as the male member may be made of aluminum or pressed steel, its engagement is entirely independent of speed and centrifugal force, no liquid lubricant is needed with attending viscosity, drag and change due to wear and temperature. Disengagement may, therefore, be made perfect. The chief disadvantage of this clutch is its size, it being more bulky than the other types with the possible exception of the dry-plate type. Inertia is also a disadvantage, as this must be as small as possible, in order to make gear shifting easy and to avoid gear clattering.

These objections led to the introduction of the multiple-disc clutch, in which the frictional surface can be made larger and the frictional force smaller per unit surface. The chief disadvantage of multiple-disc clutch is its tendency to drag if the oil in the clutch housing is not suitable for the purpose. Most makers recommend a light machine or cylinder oil and kerosene. It can readily be understood that the thinner the lubricant, the better the clutch will hold, while the more viscous lubricant will permit it to pick up its load more gradually.

To overcome the dragging evil, the dry disc type was introduced. The surfaces are not lubricated but are most generally provided with frictional facings in order to increase the coefficient of friction. This clutch has its disadvantages of inertia, similar to the cone type.

The combination of dry plate and cone has the features of the dry plate, its tendency to gradually pick up its load and the holding power of the cone after it has assumed its load. It is also simple in construction. However, it requires frequent adjustment.

At the present time, the cone, multiple disc and plate clutches are by far the most popular and seem to be holding their own, with all the new types which are being experimented with.

The Transmission.—In every gasoline engine it is absolutely necessary that some method be used for changing the relation between the speed and power of the car. When a gasoline engine is loaded above a certain limit it slows down, and the intervals between the explosion in each cylinder become so far apart as to cause the engine to labor and finally stop altogether, unless some means is used to increase the speed of the engine by decreasing the load upon it. In considering this subject it must be remembered that, when a car is using its maximum power, it may be divided either into considerable pulling power with slow speed, or high speed with low pulling power. Consequently, when a car is going at high speed and a considerable grade or a stretch of heavy road is encountered, the car will begin to slow down until the speed reaches such a point that the engine begins to knock and labor. When this point is reached, it becomes necessary to change to a slower gear, which, for the same speed of the vehicle, gives a considerably greater number of revolutions of the engine, with a consequently larger pulling power.

This pulling power is termed "torque," and if gasoline engines could be designed as to afford an increasing torque, with decreasing speed, all would be well and the transmission could be eliminated. As it is taking into account the power of the motor at several speeds, nothing of this sort can be considered. At very low speed torque becomes of greatest importance, and this is especially true in vehicle operation.

The use of the transmission is also necessary in starting the vehicle, because until the vehicle reaches a certain momentum, there is considerable load on the engine, so that a slow speed which allows a high number of revolutions of the motor must be used.

It is generally understood that to reverse the motion of the commercial car engine is to labor under disadvantages in numerous ways. Power will be lost, owing to the inferior valve timing relation which must follow if the cam shaft was designed to suit reversing condition. Unless certain complications were introduced in the valve action, and since in any case it would be necessary to add to the flexibility of the motor by the use of a transmission, it would seem unnecessary to add to the valve motion anything by the way of complicated devices. An addition to the gear set is less complicated and the end is adequately served.

Types.—The most popular transmissions are the friction, planetary and sliding gear. The friction and planetary, with few exceptions, are only used on the light vehicles, while the sliding gear type is extensively used on all sizes of vehicles.

Friction Type.—There are two types of friction transmission in use at the present writing, the single disc and the double disc. This single-disc type consists of a driving disc which is attached to the flywheel or an extension of the crank shaft, and always rotates with it and a driven disc which can be slid along a cross shaft and brought into frictional engagement with the driving disc. By moving the driven disc out from the center of the driving disc the speed can be varied from nothing to maximum, and by sliding it to the opposite side the direction of motion is reversed. Before the wheel is slid in the direction of its axis it must be disengaged from the driving disc. This is accomplished by either moving the cross shaft and its bearings or by moving the driven disc. From this cross shaft the final drive may be through a single chain to the rear axle, or it may be through a single chain to the jack shaft and then through double side chains to the road wheels. Fig. 76 illustrates a friction transmission of the single-disc type. The discs are shown in the high position, while the lower speeds are obtained by moving the driven disc in towards the center, and reverse is obtained by moving the driven disc toward the opposite side of center.

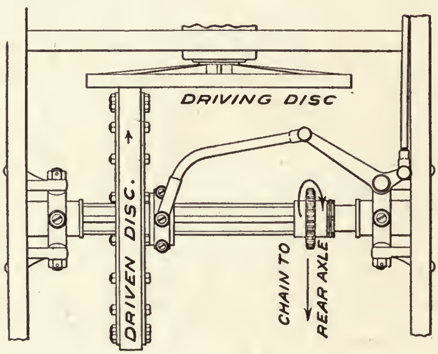

Fig. 76. Single-Disc Friction-Type Transmission.

Planetary Type.—The planetary transmission is somewhat cheaper to manufacture than the sliding gear type and also requires less skill in operation. There are two types of planetary gears, those comprising internal gears and those comprising only spur gears in their makeup. The latter is the most popular type and will be considered.

Fig. 77 depicts this type of transmission, and its principle of operation may be described as follows:

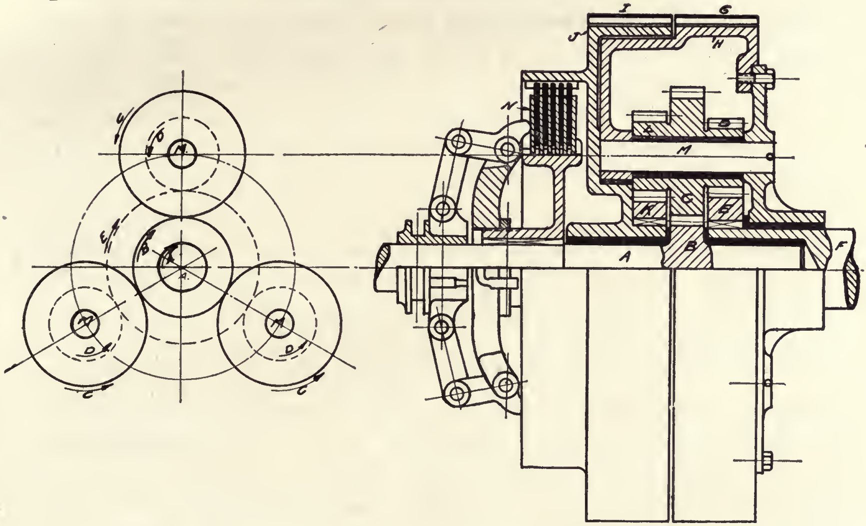

Fig. 77. Planetary Transmission with Spur Gears.

The driving shaft *A* carries the driving pinion *B*, which meshes with the planetary pinion *C*. The latter forms part of sets of three pinions which are formed integral. *D* is the low-speed planetary pinion meshing with the low-speed gear *E* which is secured to the driven shaft *F*. By applying the brake band *G* to the combined pinion carrier and drum *H*, the planetary pinions are held stationary in space and act like a back gear. Pinion *B* rotating in a right-hand direction (see end diagram), turns pinions *C* and *D* on their pin *M* in a left-hand direction, and pinion *D* turns gear *E* and the driver shaft *F* in a right-hand direction; that is, in the same direction as the driving pinion *B*.

For reverse, band *I* is applied to the drum *J*, which has the reversing pinion *K* keyed to it, being thus held stationary when pinion *B* is rotated by the engine planetary pinion *L*, is forced to roll on *K* in a left-hand direction, carrying the pinion pin *M* and pinion driver *H* with it.

Direct drive is obtained by engaging the high-speed clutch

N, which locks the reversing gear K to the driving shaft A, and since two equal gear B and K are now secured to the shaft A, the planetary pinions are locked against axial motion and the whole transmission revolves as a unit.

Sliding-gear Type.—The sliding-gear type of transmission consists of two parallel shafts mounted on suitable bearings in a housing called the transmission case. The first of these shafts is known as the primary or main driving shaft. This shaft is divided into two parts, the forward or driving part and the rear or driven part, the latter being provided with a bearing at its forward end, inside the former. The second of these shafts is known as the secondary or countershaft. The driven part of the main shaft is either squared or provided with integral keys and carries the sliding gears, whose common hubs have squared holes or keyways to coincide with the shaft to make a sliding fit upon it. The driving part of the main shaft is provided with a gear, which meshes with a gear on the countershaft and forms a drive for the latter. The countershaft has a number of gears fixed upon it, depending upon the number of speeds. The gears on both shafts are so spaced that by shifting the primary set corresponding gears on the two shafts can be brought into mesh successively without interference from the other gears. Shifting of the sliding set is accomplished by means of a hand lever located conveniently to the operator and a suitable connecting linkage. The shifter rod carries a fork, which is attached to the gears in such a manner as to permit them to rotate with their shaft.

There are two common arrangements of shafts. In some cases the countershaft is located below the main shaft, while in others the two shafts are located in a horizontal plane.

When the shafts are placed vertically the case is generally cast in one piece, with a large hole cover plate for inspection purposes. When the shafts are placed in a horizontal plane, the case may either be cast in one piece or in halves joined through the centers of the bearings.

There are three general methods of mounting the sliding gear transmission: combining them with the motor to form a unit power plant, individual mounting on a sub-frame or main frame cross members, and combining them in a unit with the jack shaft.

All of these mountings may be made with a more or less degree of flexibility. Three-point support is most generally resorted to, with the intention of relieving the case of the stresses set up by frame weaving.

Progressive Sliding Type.—In the progressive type of transmission all sliding gears are moved simultaneously when a speed change is made. The several speeds are arranged in a fixed succession as the combination of sliding gears is progressively shifted. It is thus necessary to shift into the low-speed gear first and progress to the high.

Fig. 78 is a diagrammatic view of a three-speed and reverse progressive transmission which is used on a number of heavy commercial cars.

High speed is obtained by meshing the jaw clutches formed integral with the sliding member and the constant mesh gear *F*. Second speed is obtained by moving the sliding member backward and meshing gears *D* and *E*, so that the drive is through gears *F*, *I*, *E* and *D*. For low speed the sliding member is moved backward so that the gear *B* will mesh with the gear *C* on the countershaft, and the drive is through the gears *F*, *I*, *C* and *B*. For reverse, gear *B* of the sliding set is meshed with the reverse pinion *G*, which is constantly in mesh with the

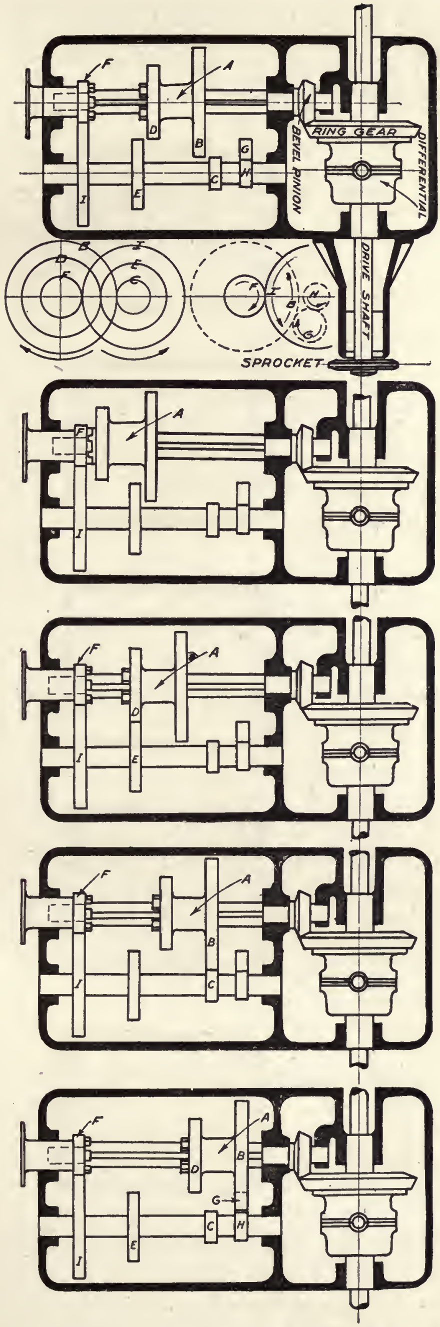

Fig. 78. Diagram of Three-Speed and Reverse Progressive Sliding-Gear Transmission.

gear *H* on the countershaft, and the drive is through gear *F*, *I*, *H*, *G* and *B*. This also illustrates a unit construction of jack shaft and transmission.

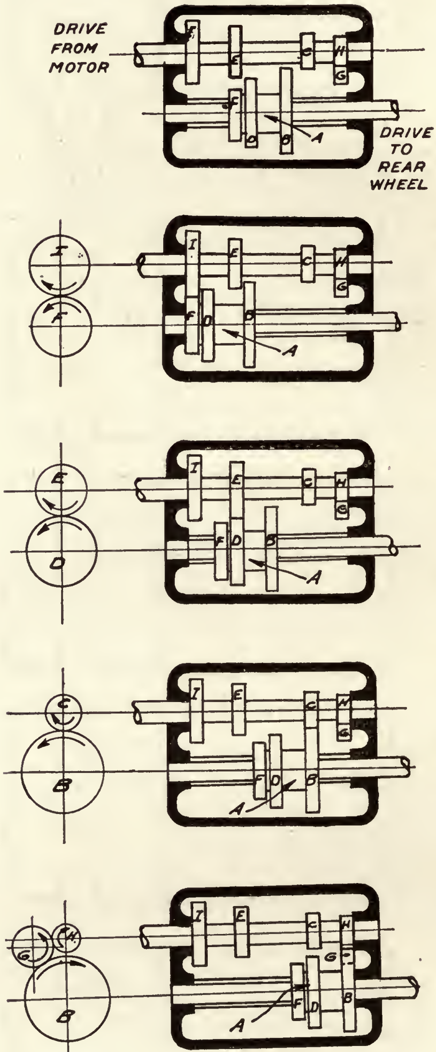

Fig. 79. Non-Direct Progressive Type.

Fig. 79 illustrates the non-direct type of change gear, the principle of operation being similar to the above, excepting that the high speed is obtained by meshing gears instead of jaw clutches, while the upper shaft forms the drive and carries the fixed gears. The lower is the driving shaft and carries the sliding gears. Since the high speed is obtained by meshing gears, the drive shaft may be constructed in one piece.

The principal objection to the progressive type is that it requires long shafts, which are likely to be inefficiently rigid and to spring and bend under the thrust of the gear teeth, causing noisy and inefficient operation. The great length of this transmission is mainly due to the fact that that the gears on each of the shafts must be spaced relatively far apart, so as to avoid interference.

Selective Sliding Type.—This objection is overcome in the selective sliding type, as two sliding sets are used. By comparing the two types it will be noted that the latter is much more compact. It also has an advantage in that the operator may change directly from one speed to any other without passing through the intervening gears.

Fig. 80 shows a three-speed forward and reverse selective type transmission. The primary shaft is squared and carries two sliding gears, which are operated by independent shifter rods. The countershaft is driven through constant mesh gears *A* and *B*, *A* being driven by the drive shaft extending from the clutch. In effecting the different speeds, gear *C* is moved forward and meshed with gear *D* for low speed, while for reverse it is moved backward and meshed with the reverse pinion *E*, which is in constant mesh with the reverse gear *H* on the countershaft. For second speed the gear *F* is meshed with gear *G*, while for high speed gear *I*, which is integral with gear *F*, is moved forward and meshed with the internal gear formed integral with the constant mesh gear *A*. This forms another type of jaw clutch, and in some cases the jaw clutch described above is used for effecting the high speed.

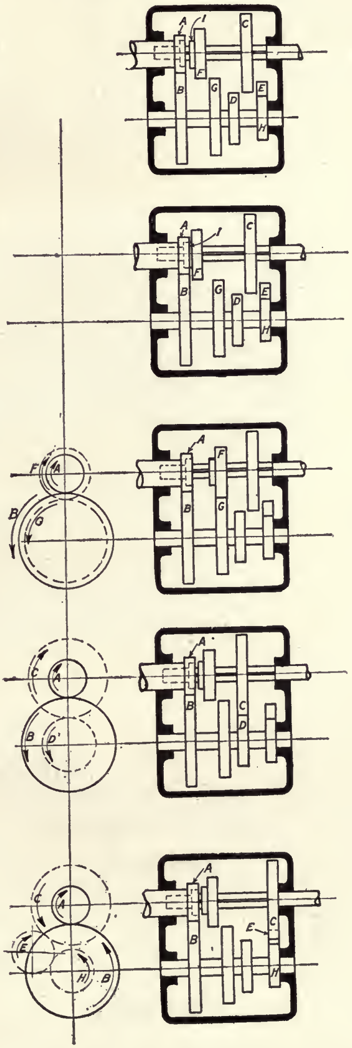

FIG. 80. Three Speed and Reverse Selective Sliding Transmission.

A typical unit power-plant transmission is shown in Fig. 81. This transmission is intended for low-powered delivery cars and is provided with ball bearings for the main shaft while the four counter-shaft gears are cut in one and are provided with plain bearings. This shows the method of mounting the clutch on the forward main shaft.

Fig. 82 depicts a typical four-speed transmission for amidship mounting. The main shaft is mounted on ball and roller bear-

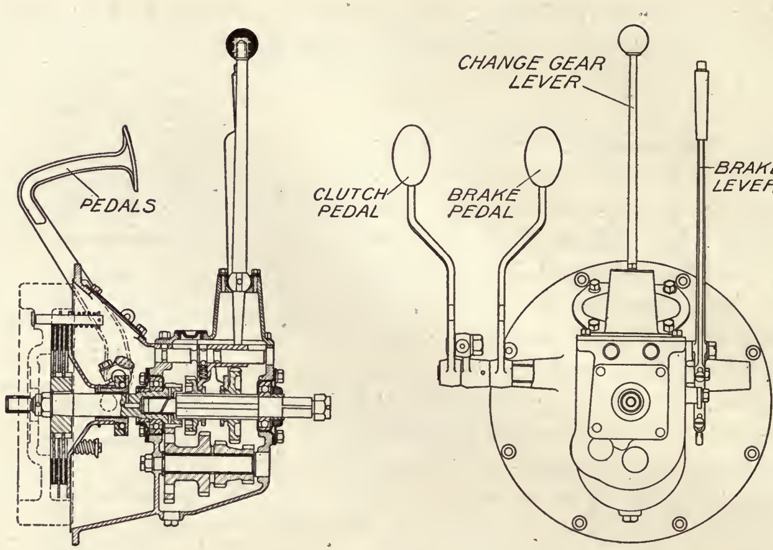

FIG. 81. Conventional Type of Unit Power Plant Transmission and Control Mounting.

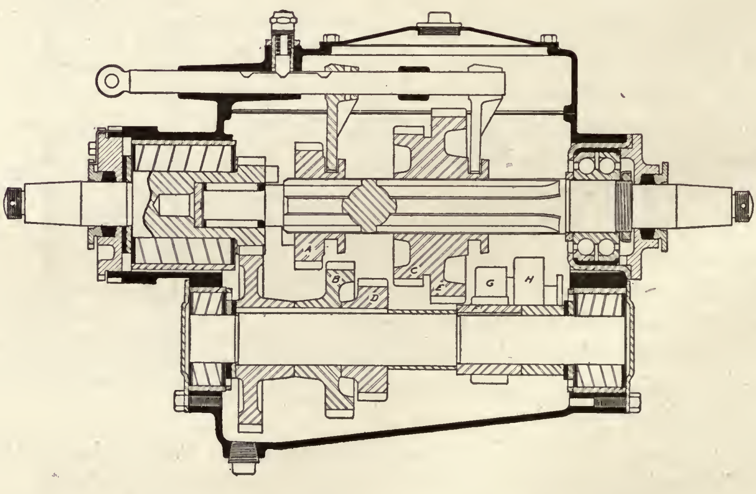

FIG. 82. Four Speed Selective Sliding Gear Transmission for Amidship Mounting.

ings, while the countershaft is mounted on roller bearings. The shifter rods are mounted in the cover and are provided with locks for the various speeds. High speed is obtained by meshing two jaw clutches this is the direct drive, third by meshing gears *A* and *B*, second by gears *C* and *D* and low speed through gears *E* and *F*. For reverse speed two idler gears *G* and *H* are used, which are so arranged that they may be moved along their shaft and meshed with gears *E* and *F*, the latter being held in its neutral position.

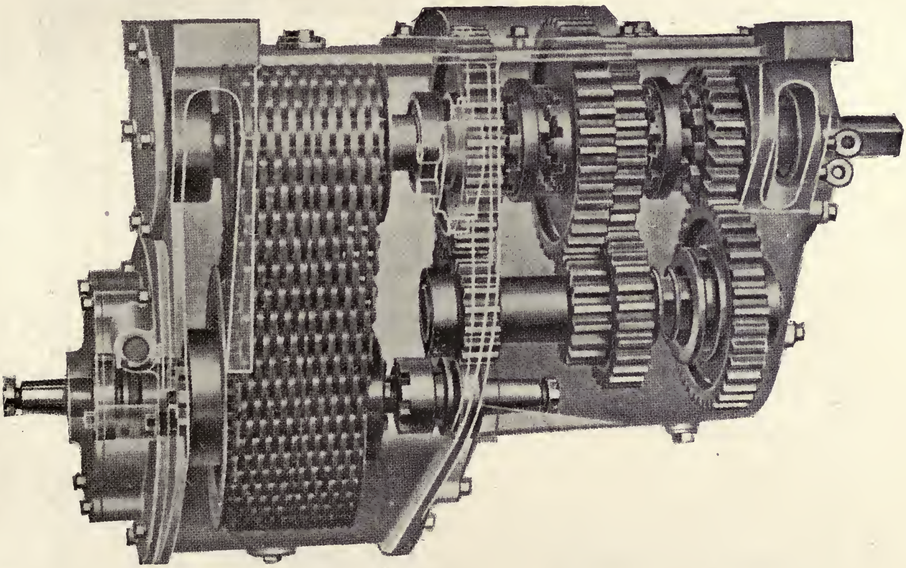

FIG. 83. Constant Mesh Type of Selective-Sliding Gear Transmission.

The positive clutch type of transmission is somewhat related to the selective sliding gear type. However, the gears remain constantly in mesh, and the gears on the main shaft are normally free to turn thereon, but may be fixed to the shaft by positive clutches. These clutches, when of the jaw type, are similar to those mentioned above, while internal and external gears may also be used as positive clutches. The gears on the main shaft are fixed while the clutches are free to slide upon keys or squared portions of the shaft.

In this type the speed changes are obtained by the individual clutches, but since the high speed is direct through the case and the speed of the countershaft is reduced through the constant mesh gears, a provision must be made so that the latter shaft

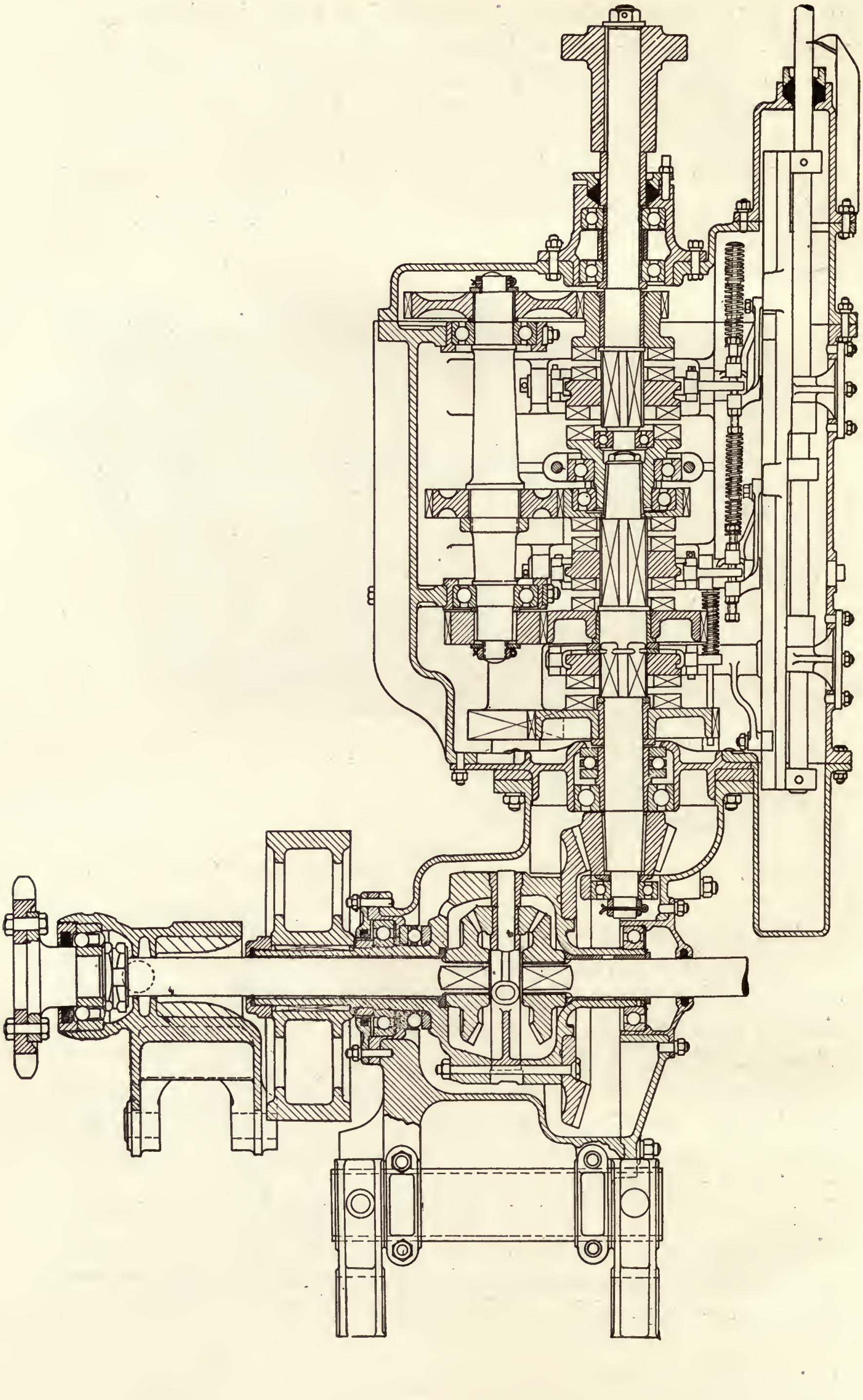

Fig. 84. Type in which Clutches are Shifted Automatically.

cannot turn on its bearings. This is accomplished by disengaging a clutch on the countershaft, simultaneously with the engagement of the high-speed clutch. Fig. 83 illustrates this type of transmission. It also presents a method of driving all four wheels by the addition of another shaft and silent chain.

An Automatic Engagement Type.—Fig. 84 illustrates the type of jaw-clutch transmission used on the Vulcan trucks. The clutches are shifted automatically and are slightly undercut so that they will not release until the driving pressure is removed, while the change from one speed to another is made by means of springs. This action is accomplished as follows: moving the gear-shift lever compresses a set of springs which control the arms which move the jaw clutches. However, as the clutches are undercut this spring action has no effect, but just as soon as the engine speed is momentarily reduced there is a tendency for the vehicle to drive the engine, which instantly frees the jaw clutch, which, under the action of the compressed springs already set by the movement of the gear-shift lever, forces the clutch to take up its new position, engaging the desired speed. This means that slightly throttling the engine and releasing the clutch will always effect the desired change of gears, but this may not take place until any desired moment after the gear-shift lever has been moved. By this arrangement it is possible for the driver to approach a hill and before reaching it, if he thinks it too steep for the highest speed, he can set the lever for the next speed. The jaw clutch will not shift as long as the engine is driving until at the desired moment on the hill, by releasing the clutch the change will be automatically effected.

Transmission gears are usually lubricated by a non-fluid oil. For easy introduction of the lubricant, a hole is provided in the cover plate, which is enclosed by a screw plug, while a drain plug is usually placed at the bottom so that the stale lubricant may be washed out with kerosene or gasoline. The bearing caps are invariably provided with felt washers, while all other parts are provided with paper gaskets, to prevent the lubricant from working out of the case.

CHAPTER VIII

UNIVERSAL JOINT AND PROPELLER SHAFT

There is a difficulty in transmitting the power of the motor to the transmission or rear axle which has to be met by a special piece of mechanism. In the chain-driven vehicle the motor and transmission usually remain in alignment when the vehicle is standing still, however, road vibrations and the nature and location of the load usually cause frame deflexions which tend to destroy this alignment, while with a live rear axle the motor is protected from bouncing up and down by the chassis springs, and the road wheels are continually bouncing over the rough surface of the road. This means that at one moment the axle is in line with the motor and the next moment it may be several inches above or below the motor center.

A rigid shaft in the case of a chain-driven vehicle would bind unless the alignment was perfect and provision made to prevent frame deflexion, while with a live rear axle the shaft would bend and bind in its bearings and the whole transmission system would be put out of commission in a short time. To overcome this, the shaft which is termed the drive or propeller shaft is made flexible to a certain extent by means of universal joints, sometimes called Hooke or Cardan joints.

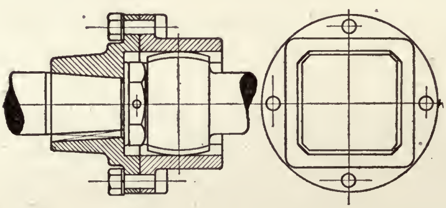

Fig. 85. One of the Simplest Universal Joints.

These universal joints serve the purpose of connecting shafts whose axles lie in the same plane, but make an angle with each other and are particularly required when the angle varies between the shafts in service.

There are various types and perhaps the simplest universal joint consists of a squared block secured to one of the shafts to be connected, fitting in a square hole in a sleeve secured to the other shaft. The four faces of the block are curved in the direction of the axis of the shaft to which the block is fastened. This type of joint is shown in Fig. 85.

Fig. 86 illustrates a somewhat different type. This consists of six internal and external teeth; the external teeth are curved in the direction of the axis of the shaft and mesh with teeth cut into the housing. This joint is provided with a pressed steel cover and packing washers to retain the lubricant. The above types may be properly termed alignment joints, since they are only used between the clutch and transmission, when only slight angular movement exists, Fig. 86 being the type furnished with all sizes of the well-known Hell-Shaw universal clutch. These joints also constitute slip joints, since they permit movement for clutch disengagement.

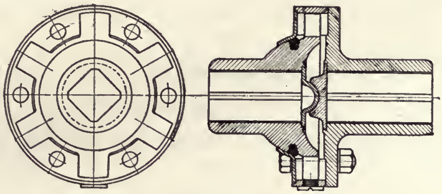

FIG. 86. Universal with Internal and External Teeth.

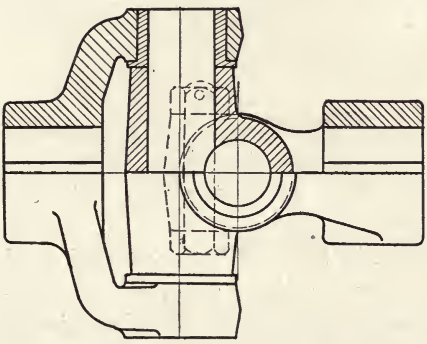

FIG. 87. Cross Type Universal with Forks.

The cross type of universal is depicted in Fig. 87 and consists of two forks, each of which is secured to one of the shafts to be connected to each of the forks by a pin. In this type of joint, the axes of the two pins do not intersect, but are at some distance from each other. However, there is an advantage in having the pins both in the same plane. This end can be attained in various ways by either using pins of different diameters and passing one through the other, by one long and two short pins, by forging the pins integral with a common center or forming them integral with the forks.

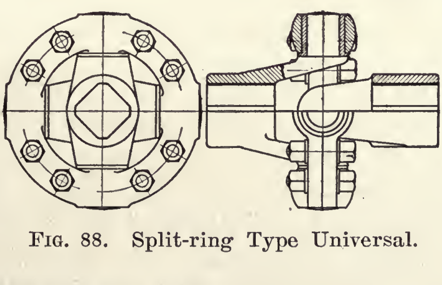

FIG. 88. Split-ring Type Universal.

In the joint shown in Fig. 88 the cross is replaced by a split ring, which carries the pin bearings, while the pins are forged integral with the forks. The ring is divided to facilitate assembling and thus permits the pins to have their axes in the same plane. This type of joint could also be made by forming the pins integral with a central ring and providing forks with separate bearing caps.

Fig. 89 illustrates the Swenson joint, which in some respects is similar to the split-ring type. It consists of a fork with integral pins and a large pin passing through a hub and supported

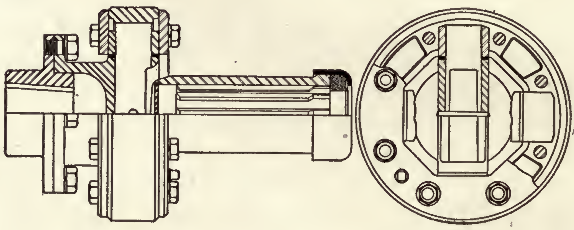

FIG. 89. Swenson Universal Joint.

by square bushings in a ring. The integral pins are also provided with square bushings which fit into slots in the ring. The bushings are held in position by two discs which together with the ring form a housing.

All universal joints are of the pin type with the exception of the leather or fabric-disc type, however, there are various methods used to provide angular movement. The Hartford joint,

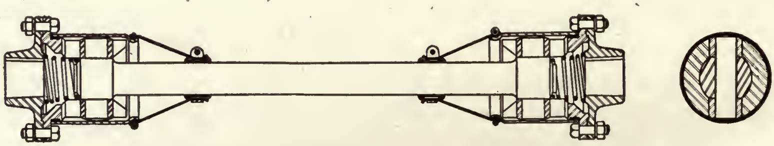

FIG. 90. Hartford Block and Trunnion Type Joint.

shown in Fig. 90, is termed a slotted shell and trunnion type. This consists of a cup-shaped steel forging secured to one of the shafts with two diametrically opposite longitudinal slots milled into the shell. The other shaft is provided with a ball-shaped end, fitting the interior of the shell and provided with a pin extending into the slots. Hardened steel trunnion blocks are interposed between the pins and the walls of the slots, to distribute the bearing pressure. This type also serves as a slip joint and is easily enclosed with a tubular steel casing and a leather boot.

Since this type of joint permits endwise movements of the shaft, some provision must be made to hold the latter in proper relation to the two joints. Coil springs are used for this purpose.

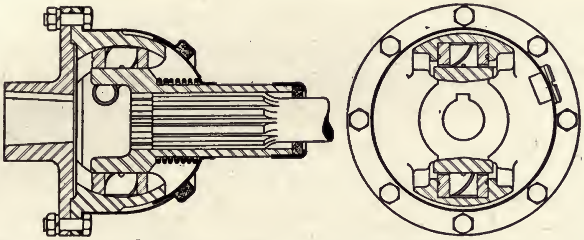

FIG. 91. Evans Type of Block and Trunnion Universal Joint.

The Evans joint (Fig. 91) is also of the trunnion type with trunnion blocks located in diametrically opposite slots; however, the outer walls of these slots are curved in the direction of the axis of the shaft, thus distributing the pressure to the three walls

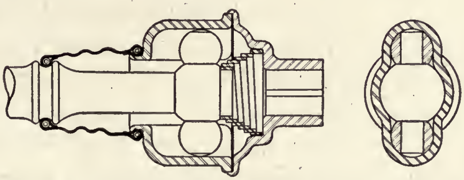

FIG. 92. Detroit Ball Bearing Universal Joint.

of the slots. The pins which carry the trunnion blocks are forged integral with the slip yoke. The joint is enclosed by a pressed steel housing provided with a packing washer and spring to retain lubricant.

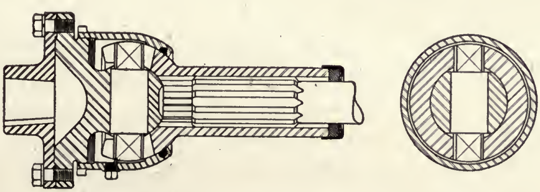

FIG. 93. The Hoosier Universal Joint.

In the Detroit universal joint shown in Fig. 92 the trunnion blocks are replaced by steel balls which operated in a pressed steel housing provided with diametrically opposite slots. The construction is similar to Fig. 89.

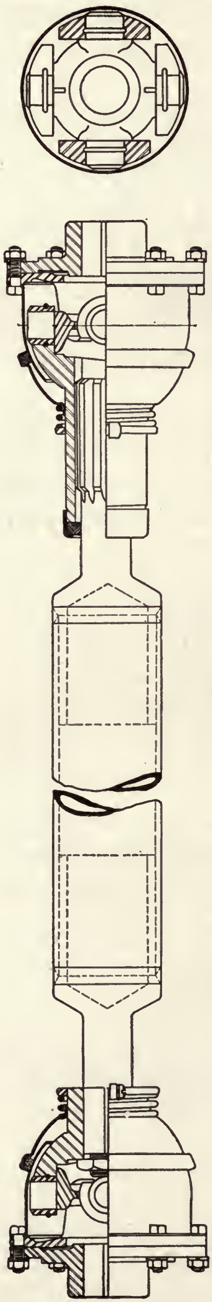

FIG. 94. Spicer Universal Joint and Propeller Shaft Assembly.

The joint shown in Fig. 93 is similar to the block and trunnion type, however, the yoke is provided with diametrically opposite slots and the pin is provided with square ends which fit into the slot. This pin is inserted through a bushing in the hub of the joint which is spherical while the housing and yoke are also provided with spherical surfaces.

Perhaps the most popular types of joints in use at present are the Spicer, Arvac, Hartford and Blood shown in Figs. 94 to 97. The Spicer joint is somewhat related to the ring type. It comprises a central ring with pins forged integral, having their axis in the same plane. One forked end is forged integral with a hub which bolts to the hub of the permanent shaft end, while the other fork may have either a short hub for permanent attachment to the propeller shaft or a long hub to provide a slip joint. The bearing ends of the fork have an opening large enough to permit inserting the pins, while they are also bored out large enough to take hardened and ground bushings, which hold the ring and its pins in position. These bushings and fork ends have circular grooves cut in them so that a soft wire can be inserted to hold the bushings in place. The mechanism is enclosed in a pressed steel housing which also serves as a retainer for the lubricant.

The Arvac joint (Fig. 95) differs from those depicted above, as it consists of a ball yoke and socket fitted with a cross block and pins enclosed in a forged steel housing. This housing supports two bushings which provide the bearings for the king pin, thus providing a light but strong driving member of tubular section. The bushings which fit into the yoke are provided with shoulders and form the bearings for the yoke pin. Bushings are provided with oil grooves and the oblong space provided by the housing forms grease pockets, this grease being oscillated by centrifugal action and this action forces the lubricant into the oil grooves of

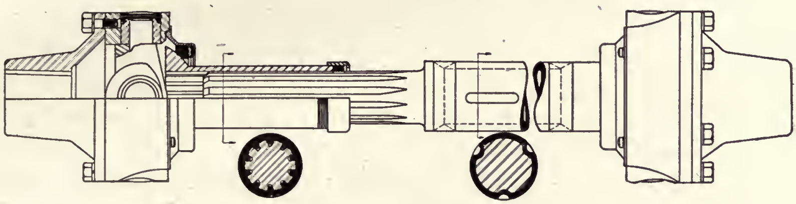

FIG. 95. Arvac Universal Joint and Propeller Shaft Assembly.

the bushings. The pins are a press fit into the cross, practically forming a one-piece driving member. The yoke end is provided with a spherical surface which with a packing contained in a retainer forms a seal to hold the lubricant.

The Hartford pin joint (Fig. 96) is of the type using one long and two short pins, and is related to the ring type in that a central ring is used which carries the bushings that form the bearings for the pins. One fork end in forged integral with a hub which bolts to the hub of the permanent shaft end. This hub has lugs in the form of a clevis so that the load is placed on

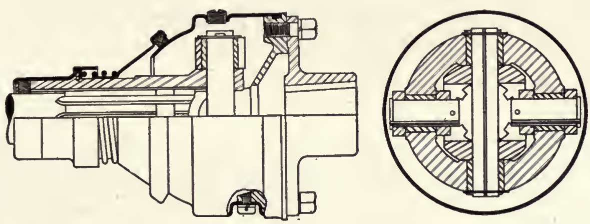

FIG. 96. Hartford Pin Type Universal Joint.

both ends of the pin instead of at one point. The long pin passes through both extensions of the yoke end and all pins are held in place by washers and cotter pins. The mechanism is enclosed in a pressed steel housing provided with packing to retain lubricant.

The Blood universal joint is depicted in Fig. 97. This is also of the pin type, however, it is of the open construction since no housing is provided. It consists of a central member in the form

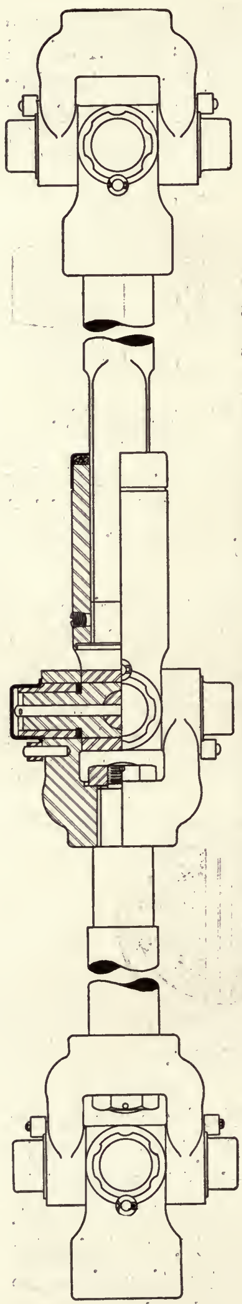

Fig. 97. Blood Bros. Universal Joint and Divided Propeller Shaft.

of a cube, which is provided with a large and small pin, the latter pin passes through this cube and large pin and is locked in position by a locking pin. The two forks are provided with bushings and the outer ends of these are enclosed by caps which contain the lubricant.

The universal joint assembly shown in Fig. 98 represents the type used on the military class A and B trucks. It is essentially a pin joint and follows accepted practice, being provided with a central cross into which the pins are pressed. In order to form a solid unit these parts are locked by a bolt which passes through them. These pins pivot in hardened and ground-steel bushings which are pressed into the fork and flange yoke. The entire assembly is enclosed in a pressed steel housing. A leather boot is attached to the propeller shaft and this with the housing forms the grease retainer.

These universals are suitable for use between the clutch and transmission and the latter and the rear axle. In commercial vehicles two universals are necessary for either location when amidship mounting is provided for the transmission. In the rear position one must always be provided with a slip joint or fitting, while when a slip joint is used at the front end it compensates for variations in shaft and frame lengths, clutch movement and is also an advantage in assembling. The slip joint in the rear must be provided to compensate for variations in the distance between the axle and the transmission due to the play of the springs. This joint may either be a square or fluted shaft with a corresponding hub or sleeve.

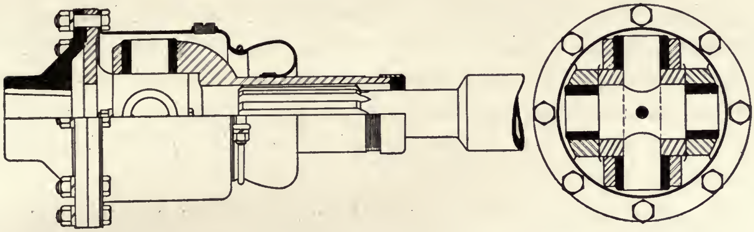

FIG. 98. Universal Joint Used on the Class B Military Trucks.

Fabric Joints.—Leather and fabric universal joints have been used for some time because they present several features not obtainable with the mechanical type. The principle advantages are silent operation without wearing surfaces requiring no lubrication. Since there is no friction they are considered highly efficient in the transmission of power. However, this joint is not adapted to conditions when there is a great angularity between shafts since the flexibility of the disc is depended upon to compensate for this angular movement and also the elongation in the shaft. Experience generally with this type of joint has not been uniformly successful and extreme care is necessary in their design. Owing to its limitations in angular movement it is mostly used between the clutch and transmission when the angular movement is relatively small.

A typical joint of this type for use between clutch and transmission is shown in Fig. 99. It consists of several similar spiders usually three armed, fastened to the ends of the shafts to be con-

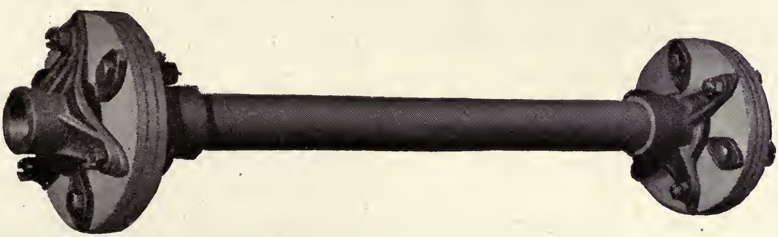

FIG. 99. Thermoid Fabric-Disc Type of Universal.

nected and of a number of leather or fabric discs bolted between the spiders. The arms of the two spiders are staggered so that any arm of one of the spiders is located midway between two arms of the other spider. Three, four or five discs may be used and individual discs are often spaced by steel washers.

Fabric discs are usually rubberized. These are built up of layers of fabric with the warp of succeeding layers at slightly different angles. In fact the whole circle is divided into a number of parts equal to the number of layers in the discs and the angle thus arrived at is the angle between the warp of adjacent discs.

Propeller Shafts.—Propeller shafts were originally made of solid section, however, with the sudden increase in shaft-drive construction, especially where the transmission was in a unit with the motor, came a decided tendency to use either two shafts and three universal joints, or a large tubular shaft and two universal joints. The advantage of the tubular lies in its reduced weight and consequently the reduced whipping effect and pressure on the bearings. A large tubular shaft is shown in Fig. 94 and a divided shaft of solid section in Fig. 97.

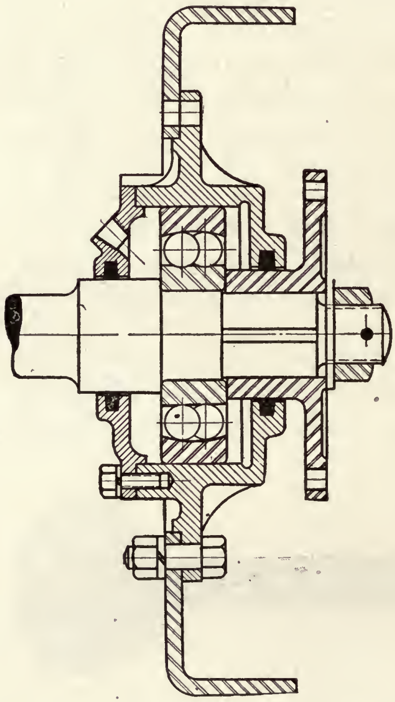

Fig. 100. Lippard Stewart Propeller Shaft Mounting.

These tubular shafts are made of 40 carbon seamless tubing and are attached to stub shaft which form the connections with the universal joints. The ends of these shafts are generally made a shrink fit into the tube and then welded. The manufacturer of the Arvac universal joint uses the shrink joint fit for shafts, but these have keyways cut into them so that the tube while being shrunk over the shaft can also be swaged into the keyways, thus strengthening the welded joints in the propeller shaft and permitting the driving strains to be taken by the swaged portion of the tube.

Propeller Shaft Mountings.—When two shafts are used a universal is generally attached to the transmission, while the other end of the shaft is mounted in an anti-friction bearing such as a ball or roller bearing. While this divided propeller shaft is not new, the use of a tubular shaft no doubt has an influence on the problem, and this center bearing is receiving considerable thought at present, which is evident through the number of designs in use at present.

The construction shown in Fig. 100 consists of a self-aligning ball bearing mounted in a housing which is bolted to a cross member of the frame. A shoulder on the shaft and the hub of the universal joint hold the bearing in position while its self-aligning feature and the end play allowed in the housing provides for frame deflexions and variations in shaft length.

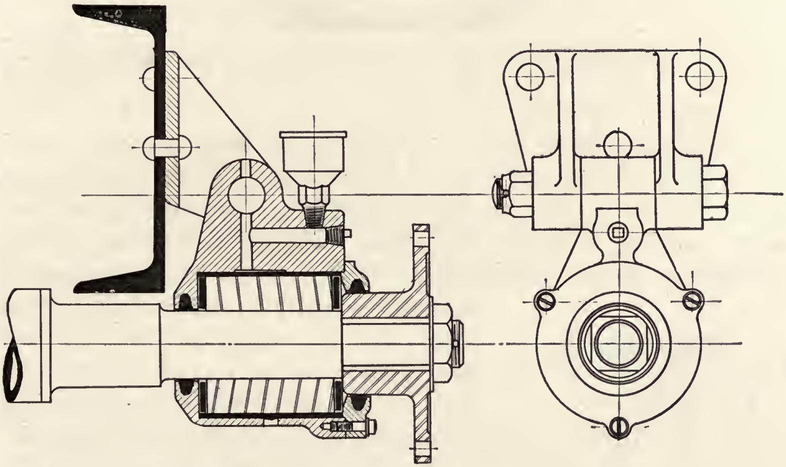

Fig. 101. Globe Propeller Shaft Mounting.

On the Globe trucks a heavy duty Hyatt bearing is mounted on a stub shaft welded to the forward propeller shaft. This bearing is mounted in a bracket which is in the form of a hinge. This type of mounting may be so placed as to provide a straight-line drive from the transmission to the rear axle, since any deflexion on the side rails of the frame may be neglected, due to the hinged bracket providing the self-aligning feature. The slip joint is mounted as close to the bearing as possible, as shown in Fig. 101.

On several models of Diamond T-trucks four universals and three shafts are used, the center being supported by two roller bearings as illustrated in Fig. 102. Two slip joints are used, one immediately back of the transmission and the other back of the center shaft mounting. The bearings are Timken rollers and mounted in a dust-proof housing and provided with adjustment.

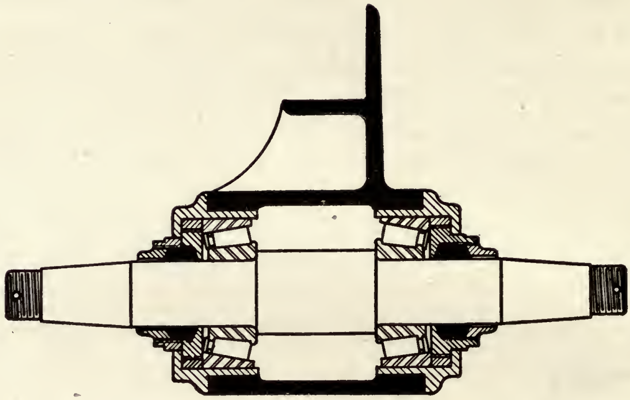

FIG. 102. Diamond T Center Bearing Mounting for Divided Propeller Shaft.

On the Bethlehem trucks the Barker floating bearing is used which permits the use of but two universal joints and a long shaft. This is depicted in Fig. 103 and is so mounted on the propeller shaft as to permit it to float between coil springs. This bearing has a free movement up and down with the propeller shaft in one of the slots of a pivoted arm. A coil spring on the shank of the bearing, which passes through the slot in the arm, slightly resists free movement of the shaft away from the arm, and another coil spring at the top of the arm acts similar in the opposite direction, the arm being pivoted at the lower end. This pivot arm is supported by a bracket attached to a cross member of the frame.

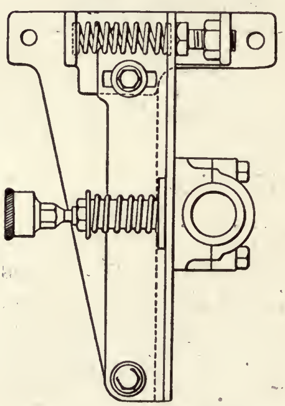

FIG. 103. Barker Propeller Shaft used on the Bethlehem Trucks.

To secure the highest efficiency and absence from vibration, care should be observed to have the pins at opposite ends of the assembly parallel, as this will eliminate vibration which may become serious if the shaft whips as the velocity of the front joint must be equalized by the rear joint, since the velocity varies during each quarter revolution. As the bearing pressures are necessarily high, proper means for lubrication must be provided. The assembly proper is usually provided with a housing to retain lubricant and means for inserting same.

CHAPTER IX

THE DIFFERENTIAL

Another unit of the power transmission system which must be used is the differential. It is a well-known fact that in turning a curve the outer wheels travel faster than the inner ones. To compensate for this a differential is used, sometimes called a compensating or equalizing gear.

If the driving wheels were solidly connected to each other by the axle and that axle driven by a chain or shaft from the center or thereabouts, great stress would be placed upon the transmission tires and other parts, owing to the fact that both wheels in turning a corner would travel at the same speed, but owing to the fact that the outside one must travel faster than the inner one, the latter would be forced around or skidded on the road.

The layman often experiences difficulty in understanding the differential, as it is always enclosed in a casing and is entirely out of sight and unless he has a chance to see it in the repair shop or factory, he has little chance to familiarize himself with its action by actual observation.

The power of the motor is applied either to a centrally divided rear axle (usually termed a live axle) or to a jack shaft, thence by chains and sprockets to the rear wheels, turning loose on a dead rear axle. The first condition applies to all shaft-driven vehicles, such as the level gear, internal gear, double reduction and worm drive, the second applies to chain-driven vehicles. The action of the differential is identical for either of the above-mentioned drives. It is mounted in the rear axle housing for all shaft-driven types, while for the chain-driven types it is mounted in the jack shaft housing.

The object of the differential is to permit of equally dividing the driving effort of a single source of motive power between the two driving wheels and to allow cars driven through wheels on opposite sides to be freely steered. In turning a corner, the driving effort must be divided in such a way that one wheel may rotate faster than the other and still receive the same driving force as the other. In other words, the driving force must be equally divided between the driving wheels under all conditions for both forward and backward motion.

The division of the driving effort is very desirable, except when the driving wheels are on ground with greatly different coefficient of adhesion. For instance, if one wheel got into a mud hole, it might not have sufficient adhesion to prevent it from spinning under the turning effort impressed by the differential gear and it would then be impossible to propel the car except by locking the differential, because the turning effort of the wheel standing on solid ground would be no greater than the turning effort corresponding to the coefficient of adhesion of the wheel in the mud hole. For this reason differential locks are often provided.

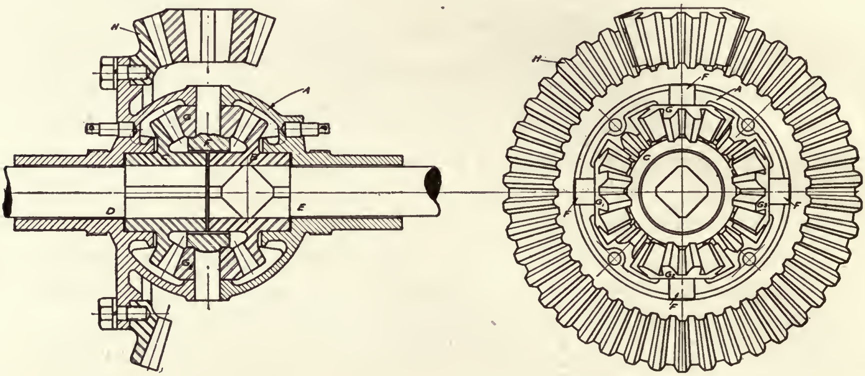

Fig. 104. Bevel-Gear Type Differential.

This lock may be left engaged as long as all four wheels move in a perfectly straight path. When, however, a vehicle is to be moved in a curved path as in turning a corner the driving wheels must revolve at different speeds, since the outer one has to cover a longer distance in the same time than does the inner wheel which is on the inside of the curve.

There are three types of gear differentials in common use, viz., the bevel type, the spur type and the helical type.

The bevel pinion type of differential, which is probably the most common form is illustrated in Fig. 104. It consists of the following parts: a housing *A*, which is usually made in halves, two bevel gears *B* and *C* secured to the differential or driving shafts *D* and *E* respectively; a two, three or four-armed spider *F*, on the radial arms of which are carried bevel pinions *G*, *G–1*, *G–2*, *G–3* meshing with both of the bevel gears *B* and *C*. To the housing *A* of the differential is usually bolted a bevel gear *H* for driving it, but this gear forms no part of the differential proper. It will be understood that the differential shafts *D* and *E*, either have secured to their outer ends road wheels or sprockets, which drive the road wheels through chains. Gear *H* meshes with the bevel driving pinion.

The action of the differential may be explained as follows: The spider *F* is held to the housing *A* and the turning effort or torque which is applied to the housing by means of the driving or ring gear *H*, and its pinion is equally divided by the bevel pinion *G* between the gears *B* and *C*. As long, therefore, as the resistance to motion of the two bevel gears *B* and *C* (in other words to the motion of the driving road wheels of the car), is the same, the two wheels will turn at the same speed. If, however, the steering wheel is turned so as to move the car to one side or the other, the driving wheel on the side to which the car turns is automatically held back with a force equal to the road adherence. The differential gear, *B* or *C* as the case may be, on that side will

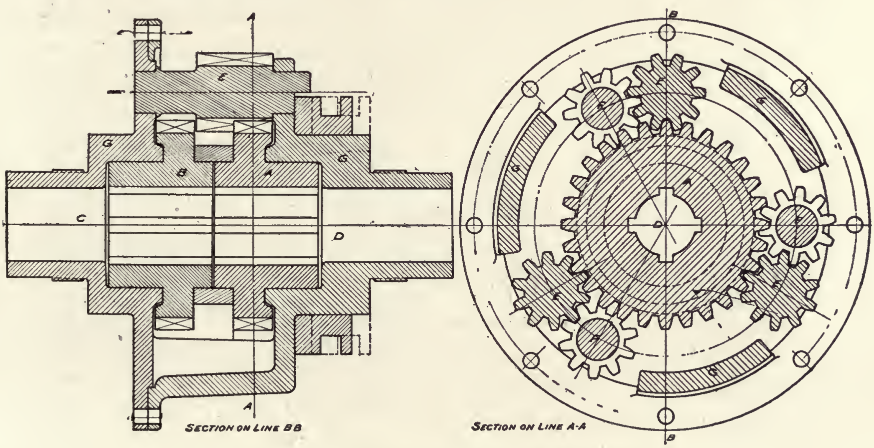

FIG. 105. Spur-Gear Type Differential.

then turn slower and its mate on the other side will turn correspondingly faster, while the bevel pinion *G* between them will turn on their journals at a speed corresponding to the difference in speed of rotation of the two bevel gears *B* and *C*. While a vehicle is turning a curve, although the speeds of the two driving wheels are unequal, the tangential forces acting at their circumference are equal.

Another form of differential which has been extensively used is known as the spur type illustrated in Fig. 105. The action of this can be best explained by comparison with the bevel type. The bevel gears *B* and *C* are here replaced by spur gears *A* and

B fastened to the differential shafts *C* and *D* respectively. While the inner sides of the hubs of these spur gears come close together, the inner edges of the gears themselves are at some distance apart. Meshing with these two spur gears *A* and *B* are two, three or four sets of spur pinions, *E*, *F*. These spur pinions have a width of face almost twice that of the spur gears *A* and *B*. The outer portion of the face of each pinion meshes with one of the spur gears, and the inner portions of the faces of the pinions mesh together. It will be readily understood that if the casing of the differential *G* is held stationary and the spur gear is revolved by hand or otherwise in a clockwise direction, the pinion *E* meshing with it is revolved in a counter-clockwise direction; the pinion *F* meshing with *E* is revolved in a clockwise direction and the gear *B* is revolved in a counter-clockwise direction. That is, gear *B* is rotated in an opposite direction to gear *A*, exactly as with the bevel gear differential. In regular operation the turning effort is, of course, transmitted to the differential housing by means of gears and the turning effort thus received by the housing is equally divided by the sets of spur pinions between the spur gear *A* and *B*, that is, between the two driving road wheels. The properties of the spur-gear differentials are exactly the same as those of the bevel-gear differential.

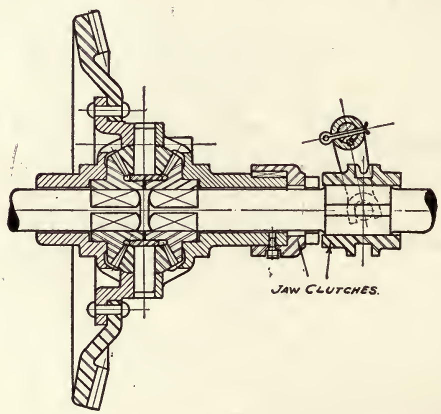

FIG. 106. A Neat and Simple Differential Lock.

The problem of working out a neat and all around satisfactory differential lock for either of the above types presents considerable difficulty, which is probably the reason that this device is not more extensively used. Fig. 106, this lock which is in the form of a four-jaw clutch, one member being keyed to the drive shaft and free to slide upon it, while the other is keyed to the differential case. Meshing the two clutch members locks the differential, since one shaft is locked against the other through the differential housing.

A differential lock can also be provided with the spur type and an excellent example is illustrated in connection with Fig. 105. A large flange is so mounted on the differential housing that it can be moved endwise, and the stud of one of the spur pinions extends beyond the housing. Half of the end of this stud is milled off so that the sliding member can be moved in, thus preventing the pinion from turning, which locks the entire differential.

The ordinary type of differential mentioned above presents certain disadvantages, the principal objection being that it promotes skidding. Recently several designs of differentials have been developed in which this common objectionable feature has been eliminated. This type is known as the helical gear type.

In the Powrlok device, there are two or more pinions mounted in the differential housing which is rotated by the engine, and also two crown wheels are attached to either driving wheel. But, in addition, there are worm gears interposed between the pinions and the crown wheels, the teeth on which are shaped to correspond. These worms are mounted in the differential casing as shown in Fig. 107 with their axis at right angles to those of the pinions. It will be seen, then, that the rotation of the differential housing in the usual way causes both pinions and worm gears to be carried around bodily in rigid relation to each other, whilst at the same time both pinions and worms have a power of rotation upon their own axis, so that they can be moved rotationally, but not bodily, in relation to each other.

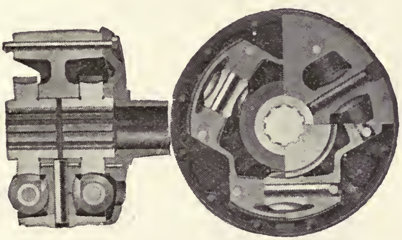

Fig. 107. Powrlok Differential.

When road resistance is sufficient to give adhesion to each driving wheel, both wheels are equally driven, the crown wheels to which they are attached being carried bodily round by the worms in which they are in engagement, just as, with an ordinary differential, they are carried round by the pinions. But when road resistance upon one wheel is reduced to a point at which it loses adhesion, and would, with the ordinary differential, start spinning, nothing of this kind happens, because the angle of the worms is such that whilst the crown wheels can drive the worms, the worms cannot drive the crown wheels, and, as a consequence, the differential is locked so far as any movement of the wheel in relation to the differential is concerned. The axle becomes for all practical purposes a solid one, and all the drive is taken by the wheel, which is for the moment supported on firm ground and can take advantage of its grip.

When both wheels are on firm ground and the vehicle is traveling freely, the differential is enabled to act in the usual manner when turning corners, by reason of the fact, already alluded to, that the crown wheels can drive the worms. Each driving wheel is attached to its respective crown wheel, and when a curve in the road is followed, the outer wheel is forced by its contact with the

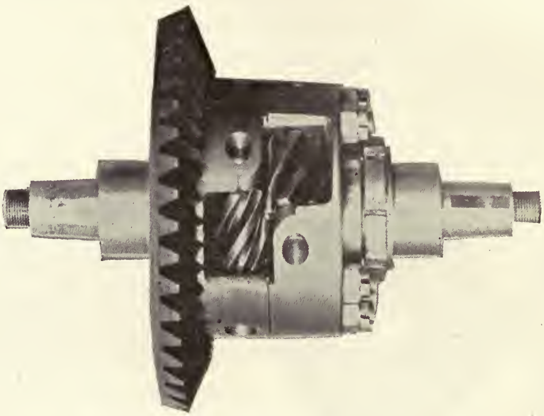

FIG. 108. Exterior of the Walter Differential.

road to travel a greater distance than the inner one. The outer wheel, therefore, revolving faster than the axle, turns the worm in connection with it and so enables the central pinions to act and react on the worms with a differential action and to distribute the power to each wheel in the usual manner.

The Walter differential (Fig. 108) is also of the irreversible worm-gear type, which drives both wheels regardless of the traction conditions of the other wheel and which still has a compensating differential action. It consists of two pairs of spiral gears mounted in a two-part housing, and meshing together and separately with worms in the housing and on the drive shafts. Both halves of the housing are alike except for the bevel or ring-gear flange. The two bolts which bolt the housing together set one-half ahead of the other so that the spiral-gear pairs mesh directly together.

The operation of this device is as follows: The driving resistance of the road wheels tends to rotate the spiral gears on their pins, but in opposite directions, but if one road wheel has a greater resistance the inequality of force cannot drive the other wheel faster as the spiral gear cannot drive the worm, so both wheels are positively driven. When turning the outer wheel rolls faster and so permits the inside wheel to turn correspondingly slower, giving a compensating differential action.

Lately there has been a tendency to substitute an equalizing gear for the differential which to certain extent eliminates its disadvantages, since this equalizing device can be so arranged as to limit the pull on one wheel to the amount required to slip the other. However, as the use of these has been limited to low-powered passenger cars they will not be considered in this chapter.

When all four wheels of a vehicle are used as driving wheels, it is generally necessary to provide three differentials; one in the transmission case to equally divide the turning effort between each pair of driving wheels and one for each front and rear drive.

Thus the differential is absolutely necessary in any form of final drive used on commercial vehicles and it presents considerable advantages in protecting all parts of the mechanism against stress when turning corners. While it also has the disadvantage of stalling a vehicle when one wheel gets into a mud hole.

This disadvantage may be overcome by providing a differential lock, this again places the responsibility upon the operator and should he attempt to round a curve with the differential locked, the tires and driving mechanism would be subjected to considerable wear. Should this be done quite frequently, the results would soon be noticeable.

In order to overcome the latter feature, this lock is operated by a foot pedal and so arranged that it must always be held in engagement. Removing the foot pressure disengages the lock, thus providing for the poor memory of the operator.

CHAPTER X

THE FINAL DRIVE

Chain, Bevel, Double Reduction, Internal Gear and Worm Drive.—From the transmission the power must be transmitted to another unit from which it is converted into useful work at the road wheels. In commercial car construction this is generally termed the final drive. There are a variety of methods of transmitting the power and in taking up the discussion of the final drive, the writer will attempt to cover this subject as clearly as possible and is offering illustrations of a number of different types in use at present. The general problem of the final drive resolves itself into the transmission of motion from one or more revolving shafts to driving wheels flexibly connected to the frame through axle and springs, and at the same time effecting a reduction in rotative speed between the driving shaft and rear wheels.

Chain Drive.—During the past years the majority of commercial cars were equipped with what is known as the double side-chain drive. The principal objection to it is the attention required to obtain maximum efficiency. It is generally exposed and dirt soon finds its way into the numerous bearings, causing rapid wear. For a time, chain cases seemed to be the solution of the problem, but they are not satisfactory and most makers started experimenting with different types of shaft drives. This has resulted in the introduction of the bevel gear, double reduction, internal gear and worm gear rear axles.

In chain drive the power must be transmitted to a unit carrying the driving sprockets, the differential and in some cases a set of brakes. This unit is generally termed the jack shaft and may be built integral with the transmission or in a separate unit, mounted separately or bolted to the transmission. This jack shaft is similar to and performs the same functions the bevel gear rear axle in pleasure cars, excepting, of course, that it does not carry the weight of the vehicle. For this purpose a dead rear axle is used, which has spindles upon which the wheels and their bearings are mounted. Various types of rear axles may be found in use at present, their section being either round, square, rectangular or I-beam. The jack shaft is usually equipped with one set of brakes, while the other set is mounted in the rear wheels. However, some makers mount both sets of brakes on the rear wheels.

Some method must be provided to take up the driving thrust from the rear axle to the frame. For this purpose a radius rod is provided, which also takes up the brake pull, and the reaction due to chain pull, as well as allowing for adjusting the slack in the chain. These rods are generally of the full universal type, being pivoted on the jack shaft and the brake support or spindle of the rear axle. They are sometimes provided with large coil springs to take up abnormal shocks, when engaging the clutch or backing up to a curb.

The chain drive in reality is a double reduction through two units, one reduction being obtained through the bevel gears in the jack shaft, while the other is obtained through the jack shaft and rear wheel sprockets.

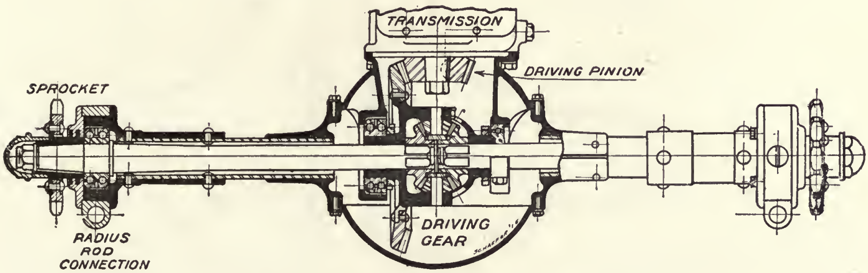

Fig. 109. Sheldon Jack Shaft.

Fig. 109 illustrates the jack shaft built by the Sheldon Axle and Spring Company, which was used on a number of commercial cars, being a separate unit so arranged that a standard transmission may be bolted to it. The differential is of the bevel-gear type, while the working parts are mounted on ball bearings.

Fig. 110 depicts the Velie jack shaft which is a separate unit, the transmission being mounted on a sub-frame, while the jack shaft is mounted on the main frame. Like the Sheldon construction, the driving unit is so arranged that it may be removed through the inspection cover opening without removing the jack shaft unit from the chassis. The differential lock is also shown, mounted on the right side of the differential housing. The jack shaft is flexibly mounted on the frame, while a torque arm is used to hold it in alignment. The differential and drive shafts are mounted on roller bearings. Internal expanding brakes are pro-

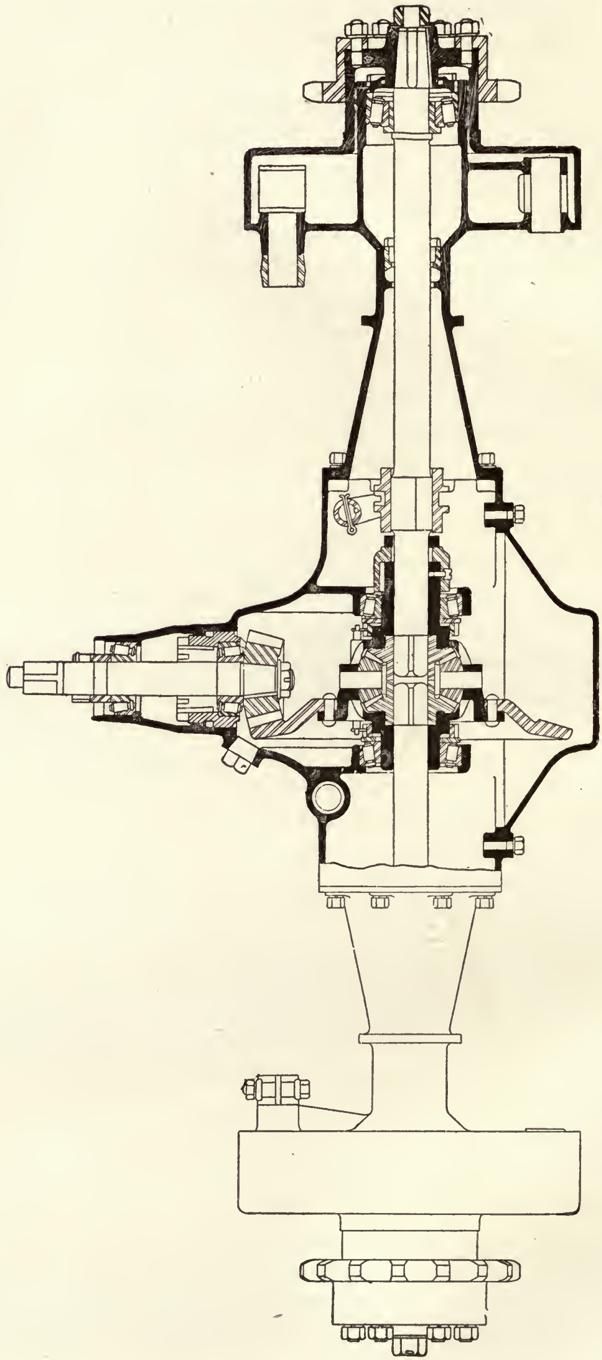

FIG. 110. Velie Jack Shaft.

vided. The outboard bearing for the sprocket is mounted as close as possible to the chain center, so as to overcome the high tension in the chain on low gear.

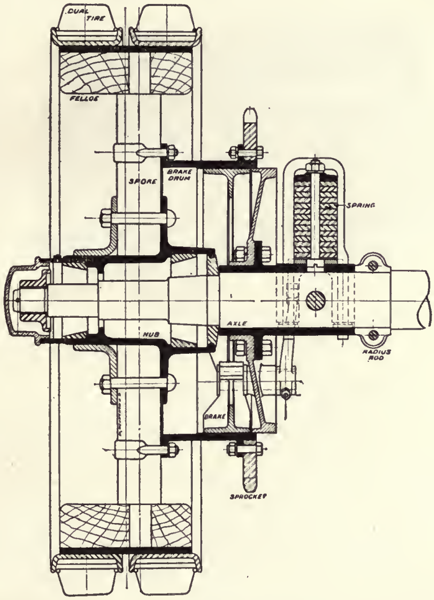

Fig. 111. Velie Rear Axle.

In Fig. 111 is shown the Velie rear axle which is of round section, having a spring seat, which also carries the brake spider keyed to it by a large bolt. The spring is mounted above the axle and retained by spring clips. The radius rod is mounted inside of the spring and pivots on the rear axle spindle. Internal expanding brakes are mounted inside the brake drum, to which the driving sprockets are attached. This drum is attached to the spokes of the wood wheel by spoke clips, while the wheels are equipped with dual tires. Wheels have roller bearings.

Fig. 112 illustrates the radius rod used on the Atterbury chain-driven models. This rod is of the universal type, being pivoted and hinged to jack shaft at the forward end and hinged to the

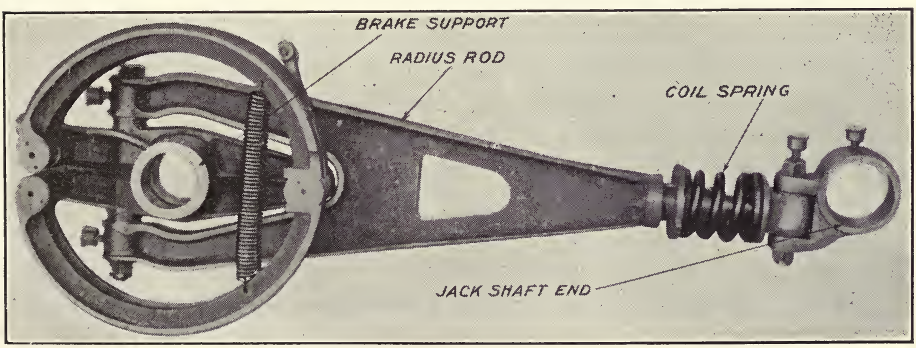

Fig. 112. Atterbury Radius Rod.

brake support at the rear end, which in turn is found to pivot on the rear axle spindle. An adjustment is provided at the forward end on which is mounted a heavy coil spring. The rod is constructed in two sections, so that the rear end may slide upon the forward end, the spring holding both ends in their positions. When the clutch is suddenly engaged or when backing up to a curb, this spring takes up the abnormal shock by compressing and permitting the rear section to slide over the forward one. As soon as the force is removed the spring expands and returns the rear end to its proper position. This type of radius rod is also used on the Velie and Lewis commercial cars.

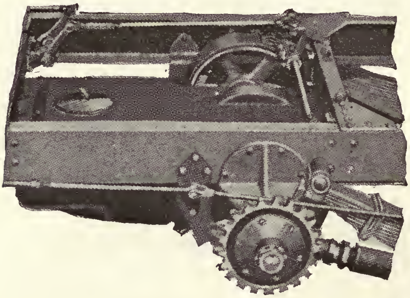

FIG. 113. Peerless Jack Shaft Intregal with Transmission.

On the Peerless truck, the jack shaft is built integral with the transmission as shown in Fig. 113. It is similar to the construction described above, excepting that one set of brakes is mounted on the jack shaft inside of the frame and anchored to the frame cross-member instead of to the housing proper. The shafts are not enclosed, but are mounted in anti-friction bearings attached to the frame. With this construction the brakes are better protected from mud and water. Construction of this type may also be found on several other cars.

The Vulcan radius rod and rear axle construction differ somewhat from the above in that the radius rod adjustment is placed at the rear instead of the customary place near the jack shaft sprocket. By referring to Fig. 114, it will be noted that the radius rod proper is similar to a marine engine connecting rod with caps bolted to the jack-shaft end which fit over a spherical bearing. The rear end has three bosses, through which are inserted two guide pins and an adjusting screw. These guide pins are retained by clamping bolts, while the adjusting screw is attached to a yoke, through the outer ends of which the guide pins pass. A large bolt passes through the heads of these and through a bracket which pivots on the axle spindle, formed integral with the brake support. The hub and brake drum are cast integral and attached to the wheel by bolts and the wheels are mounted on roller bearings.

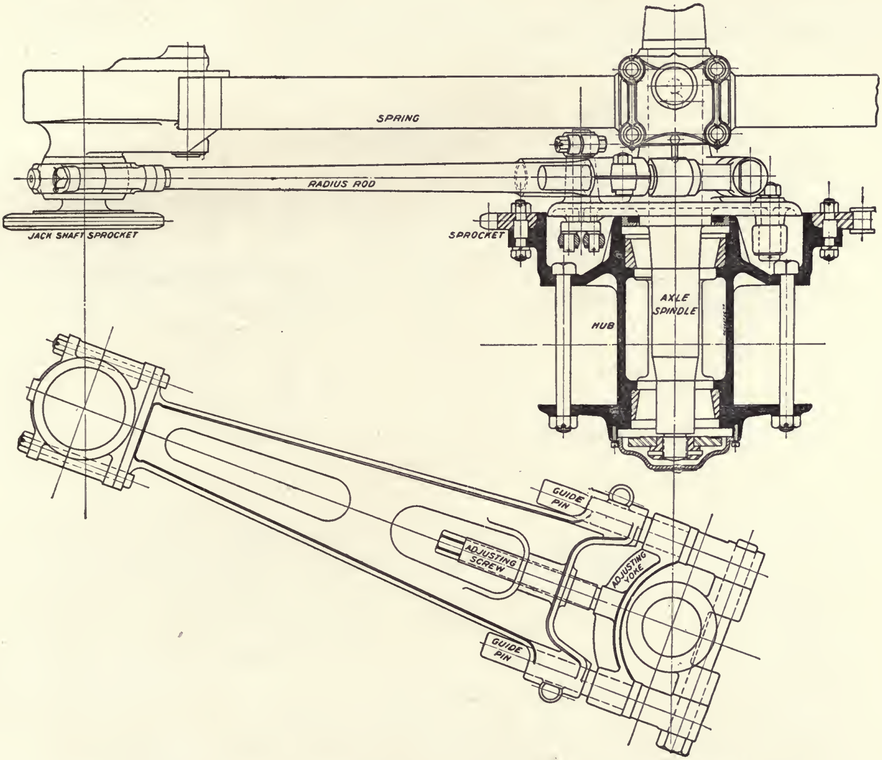

FIG. 114. Vulcan Radius Rod with Adjustment at Rear End.

The Kelly jack shaft (Fig. 115) illustrates a pressed steel housing and a full floating construction which is quite accessible. The housing proper is pressed in two halves and welded together, while reinforcing tubes and flanges are used to strengthen it. To this pressed steel jack-shaft housing is bolted a cast steel differential carrier or housing which carries the entire differential assembly and also the transmission. Provision is made for inspection of the differential assembly by removing the pressed steel cover from the rear of the jack-shaft housing. Each end carries a supporting roller bearing mounted in sleeves and held in place by the carrier and caps. An adjusting nut screws over each sleeve, where it is easily accessible and is locked by a small key on the carrier cap.

The outer end of the jack-shaft housing terminates in ball sleeves, which are riveted to it. These sleeves provide universal movement for the entire unit when mounted in the chassis frame and also a universal movement for the forward end of the radius

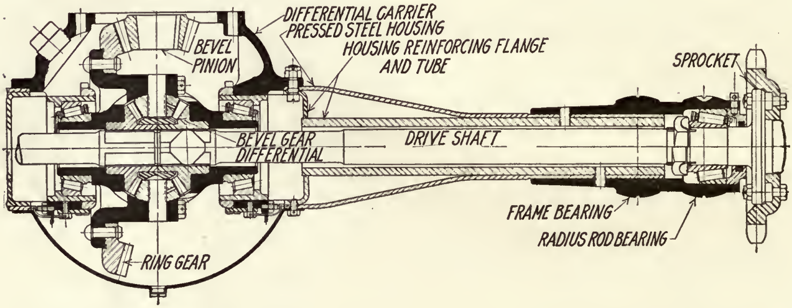

Fig. 115. Kelley-Springfield Floating Jackshaft with Pressed Steel Housing.

rod. The ball sleeves accommodate a roller bearing held in position against the shoulder of the drive shaft by a large lock nut properly secured by lock wires. A large adjusting nut, containing a felt washer screwed into the end of the ball sleeve, bears against the outer race of the bearing. Sprockets are bolted to the flanges forged integral with the drive shafts and the bolts are equipped with hardened steel bushings. They afford equal distribution of the shearing strains on the bolts, due to the drive of the truck.

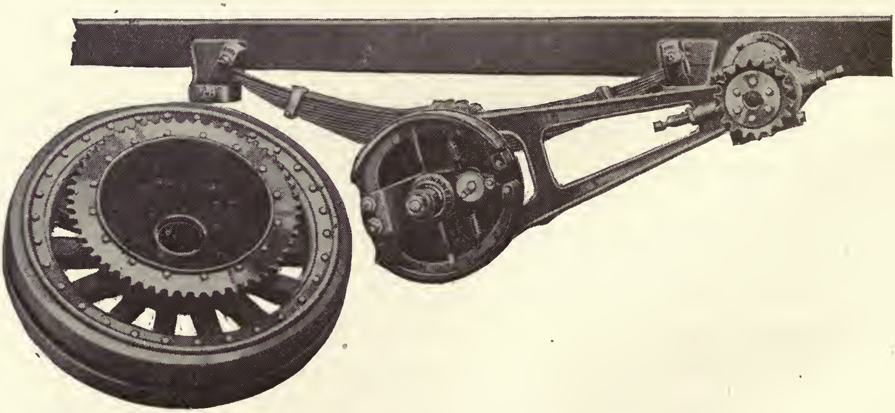

Fig. 116. Kelley Radius Rod, Brake and Rear Axle Construction.

Fig. 116 illustrates the radius rod and double rear wheel brakes of the Kelly trucks. The radius rod proper is a drop forging and pivots from the brake spider. The chain adjustment is incorporated at the front end by adjusting screws. The rear axle is of I-beam section with integral spring pads.

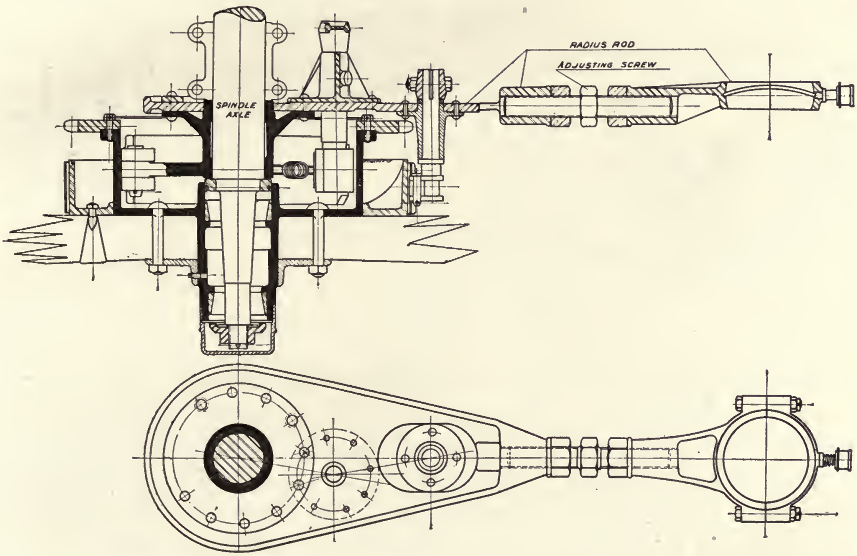

Fig. 117. G.M.C. Radius Rod and Rear Construction.

The G.M.C. one-, one-and-a-quarter and two-ton models have similar constructions excepting for size, which varies on the different capacities. This is illustrated in Fig. 117, showing the two-ton construction. The rear axle is of rectangular section and has a long spindle upon which the spring seats, brake spider to which the radius rod body is riveted and the wheels are mounted. The hub and brake drum for the internal brake are formed integral, while a separate brake drum is attached to the wheel spokes for the external brake, both sets of brakes being mounted in wheels operating on separate drums. The radius rod has the brake shaft bearings riveted to it, so that all brake reactions are taken on the radius rod. This radius rod is divided into a front and rear part, each having a large threaded boss to receive the adjusting screw. This screw has right and left-hand threads and is locked by lock nuts. The front end of the rod is divided on the jack-shaft center and is provided with a spherical surface to give universal movement.

An enclosed chain drive is illustrated in Fig. 118. This construction has been used on the Natco one-ton trucks for several years. The case is cast in two parts and well ribbed, so that it can be used as the radius rod also. The forward end carries the adjusting member, which is in the form of an eccentric and pro-

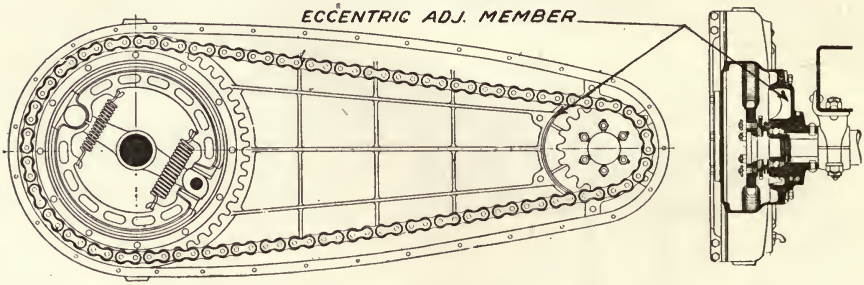

FIG. 118. Enclosed Chain Drive.

vides a spherical bearing to obtain universal action. The rear end pivots about the brake drum, in which are mounted double expanding brakes. The rear wheel hub and brake drum are cast in one piece to obtain proper strength for this construction, since the thrust is transmitted through the brake drum. Ground joints are used to prevent oil leaks, while drain plugs are also provided so that the case can be cleaned at intervals.

The advantages of the chain drive are low cost of changing gear ratios, minimum unspring weight, somewhat greater flexibility, mounting of differential on chassis, where it is protected by the vehicle springs, and greater accessibility, for broken links can be repaired easily. When it is kept clean, oiled and properly adjusted it is a very efficient means of power transmission; however, this is quite a difficult problem. This naturally suggests enclosed chain drives which operate in oil; however, a practical chain case is a difficult problem, so that many joints and bearings are necessary, which are subject to frequent renewal and in service the chain case soon becomes more noisy than the open drive. It also makes a somewhat inaccessible construction, thus increasing maintenance cost.

The Bevel-gear Axle.—The bevel-gear axle is almost universally used on pleasure cars. However, it is not very popular on commercial cars, being used only on the light vehicles of capacities up to 1,500 lbs. Its use is limited, owing to that it is very difficult to provide a higher reduction than four or five to one without sacrificing road clearance.

Fig. 119 depicts the G.M.C. 1,500-lb. delivery car bevel drive rear axle, which is of the three-quarter floating type. The axle housing is divided into two halves having tubes riveted into it, which extend slightly beyond the wheel bearing. The differential is of the bevel-gear type and mounted on Hyatt roller bearings

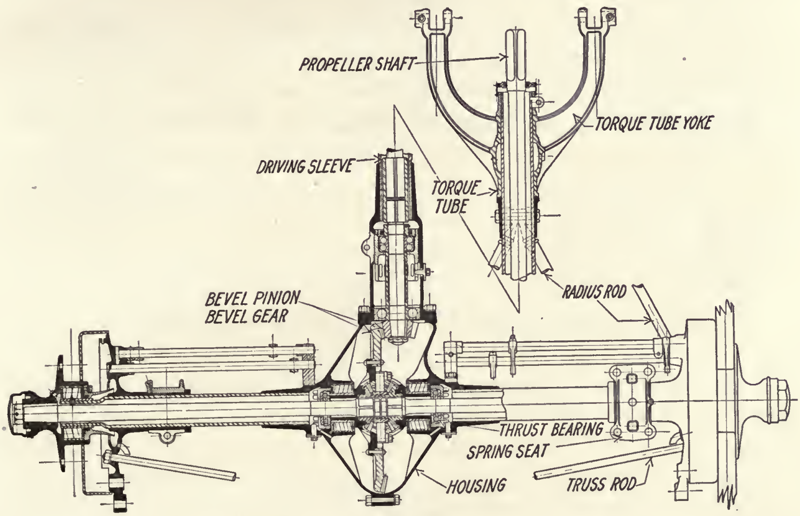

FIG. 119. G.M.C. Delivery Car Bevel Gear Type Rear Axle.

inside of the axle housing. Ball thrust bearings with ample adjustment are mounted on each side of the Hyatt roller bearings to take up the thrust load of the gears. The hub is provided with a Hyatt bearing, which is centered under the wheel and is retained by a threaded retaining member which has a funnel-shaped part formed integral to throw off the oil and prevent it from reaching the brakes. The hub is keyed to axle shaft, so that the weight is carried on the housing tube, while the shaft transmits the power. The spring seat swivels upon the brake spider, which also carries the ends of the truss rod. The axle housing has a bracket to support the brake shafts, so that the levers can be mounted close to the center of the axle. The brakes are of the internal and external type and operate on pressed steel brake drums bolted to the wheels. The propeller shaft is enclosed in the torque tube, which is bolted to the axle housing and carries the ball bearings for supporting the bevel pinion, while the pinion shaft and the propeller shafts have squared ends and are connected by a sleeve having a square hole fitting over the squared shaft ends.

The torque is taken by the torque tube through a large fork, which is hinged to a heavy cross member, while the spring is free at both ends. Radius rods, running from the brake spider diagonally to a point directly back of the torque tube fork, take up the thrust load.

Bevel gear drive axles of similar construction are also on the Steward, Commerce, Vim and other light delivery cars. They are mostly used with pneumatic tires, where speed is a factor.

Types Intended to Overcome Reduction Difficulties.—The difficulty with the bevel-gear axle is overcome in the double reduction, internal gear and worm-gear axles. The double reduction and the internal gear type use two reductions, one by bevel gears and the other by spur gears, while in the worm-gear axle a large reduction can be obtained with a single pair of gears.

The advantages claimed for the double reduction are silent operation, enclosure of all working parts, while the differential bearings are relieved of thrust loads. By mounting one pair of gears above the other, approximately straight-line drive can be obtained.

The internal gear-drive axle possesses the advantages of silent operation and enclosed working parts. However, the differential bearings are subjected to thrust loads, since the spur gears are mounted in the wheel, and it is also difficult to obtain a straight-line drive. They possess an advantage in that this axle is divided into two units, the jack shaft which transmits the power and the dead rear axle which carries the weight. The jack shaft is similar to the chain drive jack shaft and may either be bolted to the front or rear of the dead axle.

The worm-gear axle is probably the most simple construction, since it has the least number of parts, can easily be arranged for straight-line drive, and possesses the features of silent operation, protection of parts subject to wear and a wide range of gear ratios can be provided without changing the distance between the worm and the wheel.

All types of shaft-driven axles can be made quite accessible so that maintenance can be held within reason. The double reduction and worm-gear axles are generally of the full floating type, in which the weight is carried on the axle tubes and the shafts are subject to only torsional stresses, as they only transmit power.

The Double-reduction Axle.—One of the first commercial car builders to use a shaft-drive axle was the Autocar Company, which equips all of its models with double-reduction axles. Extensive refinements have been made on this axle and it presents an

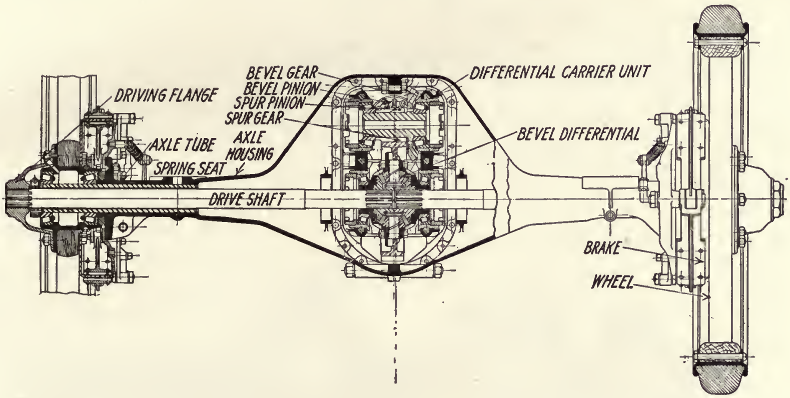

Fig. 120. Double Reduction Axle used on the Autocar.

excellent type of double reduction. This axle is shown in Fig. 120, and is what is termed a full-floating axle. The bevel gears are placed above the spur gears so that a straight drive can be

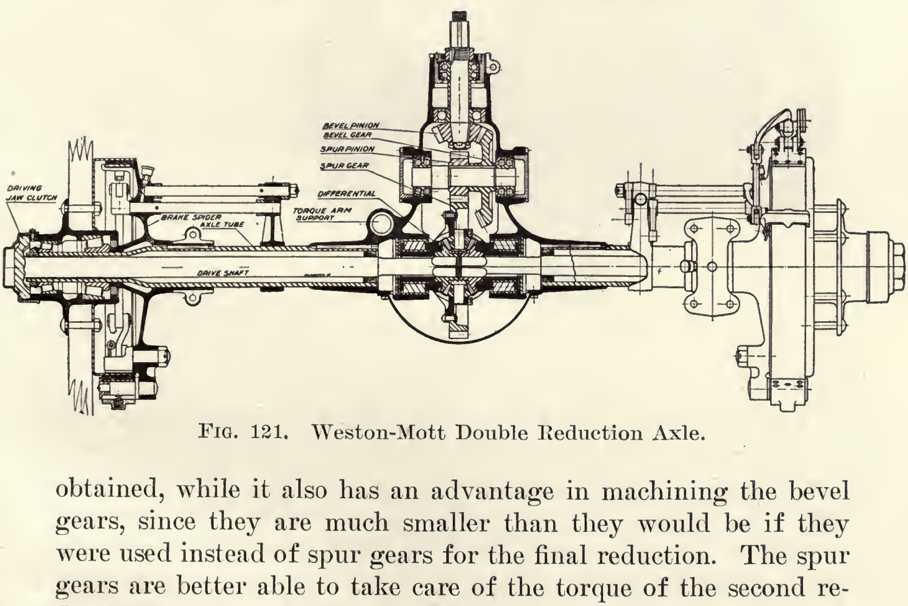

Fig. 121. Weston-Mott Double Reduction Axle.

obtained, while it also has an advantage in machining the bevel gears, since they are much smaller than they would be if they were used instead of spur gears for the final reduction. The spur gears are better able to take care of the torque of the second reduction and the differential bearings are relieved of the high thrust loads, which they would be required to carry if bevel gears were used.

The axle housing proper is cast in two halves joined together at the center. The spring seats are cast integral and the end of the housing is provided with a flange to which the brake spider is bolted. A reinforcing tube is placed into the housing, which extends a little beyond the spring seat, the end of which carries the wheel bearings. The bevel and spur driving gear and differential are mounted in a unit in the differential carrier and bolted to the housing proper. The drive shafts have splined ends and the wheel drive is taken through flanges bolted to the hub. Internal and external brakes are mounted on the brake drums inside of the wheels.

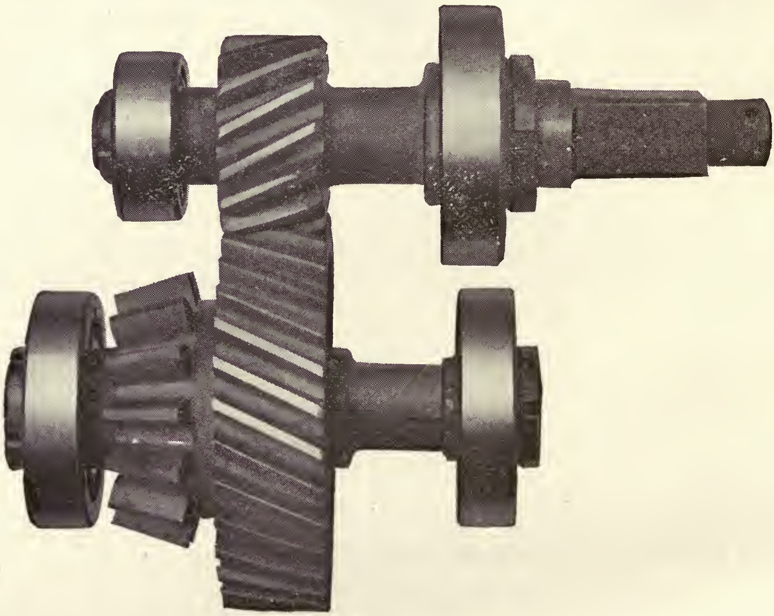

Fig. 122. White $1\frac{1}{2}$ Ton Double Reduction Axle with Helical Cut Spur Gears.

Fig. 121 illustrates a double-reduction axle of one-ton capacity, which was placed on the market several years ago by the Weston Mott Company, and was used on the Menominee, Flint and other light commercial cars. This axle is also of the full floating type, but differs from the one described above in that straight-line drive cannot be obtained since the bevel gear set is mounted in front of the spur gear set instead of above it. The differential carrier has an extension on each side into which are placed the axle tubes, while a large cover is provided for inspection purposes. The brake spider has a hub which is keyed to the axle tube and upon which the spring seat can pivot, while the brake operating levers are also brought inside of the frame. The drive for the wheel is through a jaw clutch, the male member of which is forged integral with the drive shaft, while the female member is formed integral with the hub.

The Autocar is designed to take both torque and thrust through the spring, while the Weston Mott axle may be arranged with radius rods to take the thrust load and a torque arm to take the torque load.

The one-and-one-half ton White truck is also equipped with a double-reduction axle (Fig. 122) which differs from the above in that the bevel gears are in the customary place as in the pleasure car axle. The propeller shaft carrying the spur pinion which has helical teeth, is mounted above the short shaft carrying the helical spur gear and bevel pinion. Both shafts are supported by ball bearings at each end and provision is made to take care of the thrust of these gears. This presents another method of approximately a straight-line drive, while the torque is taken through the springs and the driving thrust by radius rods.

The double-reduction drive, like the worm drive, will be found on both gasoline and electric vehicles, although its use seems to be mostly on vehicles of 5,000 lbs. capacity and under.

The Internal-gear Drive.—As mentioned above, the internal-gear drive axle is really a double reduction, in which two sets of gears are used. It is also similar to the chain drive in that a jack shaft and dead rear axle are used. However, the two units are

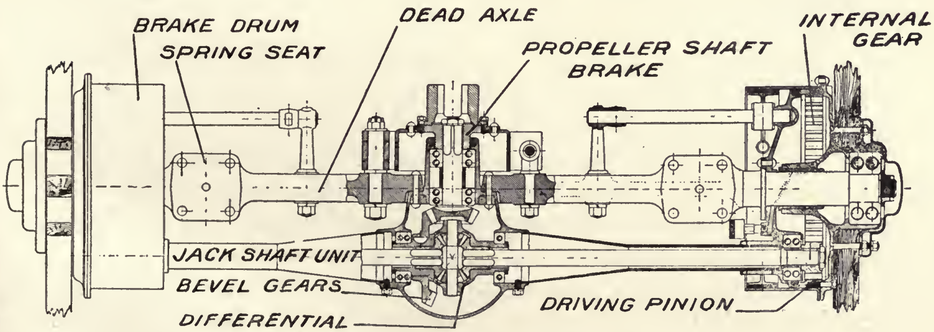

Fig. 123. Fremont Mais Internal Gear Axle.

bolted together and the sprockets and chains are replaced by internal gears in the brake drums and spur pinions on the drive shafts. Among the users of this type of axle may be mentioned the General Vehicle Company, Fremont Mais, Mais, Denby, Republic, Stewart and numerous others.

Fig. 123 serves to illustrate the Fremont-Mais one-and-a-half-ton axle, showing a dead rear axle of I-beam section with integral spring seats and spindles carrying a bronze sleeve and a double row ball bearing upon which the wheel is mounted. The jack-shaft unit, carrying the differential, drive shafts and bevel driving gears, is mounted to the rear of the I-beam axle. The housing of this unit is riveted to the axle and supports tubes which enclose the drive shafts and extend into the brake spider to support the wheel brakes. The drive shafts float in the differential and are supported inside the brake spider by a double row ball bearing next to the spur driving pinion. The hub flange is made large enough so that the brake drum can be riveted to it, while inside the brake drum and bolted to the hub is the internal gear. The driving gear, with its bearing, is enclosed in a separate compartment formed by the brake drum, spider and hub and works in a bath of oil. One set of brakes is located in the wheel drums while the other is mounted on the bevel pinion shaft and supported from the rear axle. This brake acts on both wheels through the driving unit.

Fig. 124 depicts the massive construction of the Studebaker internal gear drive rear axle which possesses several unique features, having a dead rear axle on which are mounted the bevel gear differential and drive shafts which comprise the jack shaft, while the wheels are driven through spur pinions meshing with internal spur gears. The whole mechanism is enclosed and felt packings are provided to keep out dust and retain grease and oil in the various compartments.

The principal difference between this axle and that above is the scheme of the brakes. In front of the bevel gears housing is a very wide brake drum on the bevel pinion shaft. On this drum are the two brake bands for foot and ratches hand brakes, but an additional hand emergency brake is provided not ratchet retained. It consists of shoes acting upon V-shaped ribs running around on the outside of the internal gears on the rear wheels close to the spokes. It is claimed that this construction relieves all brakes from any danger of slipping due to leakage of grease around the rear wheels and yet provides a brake acting upon the

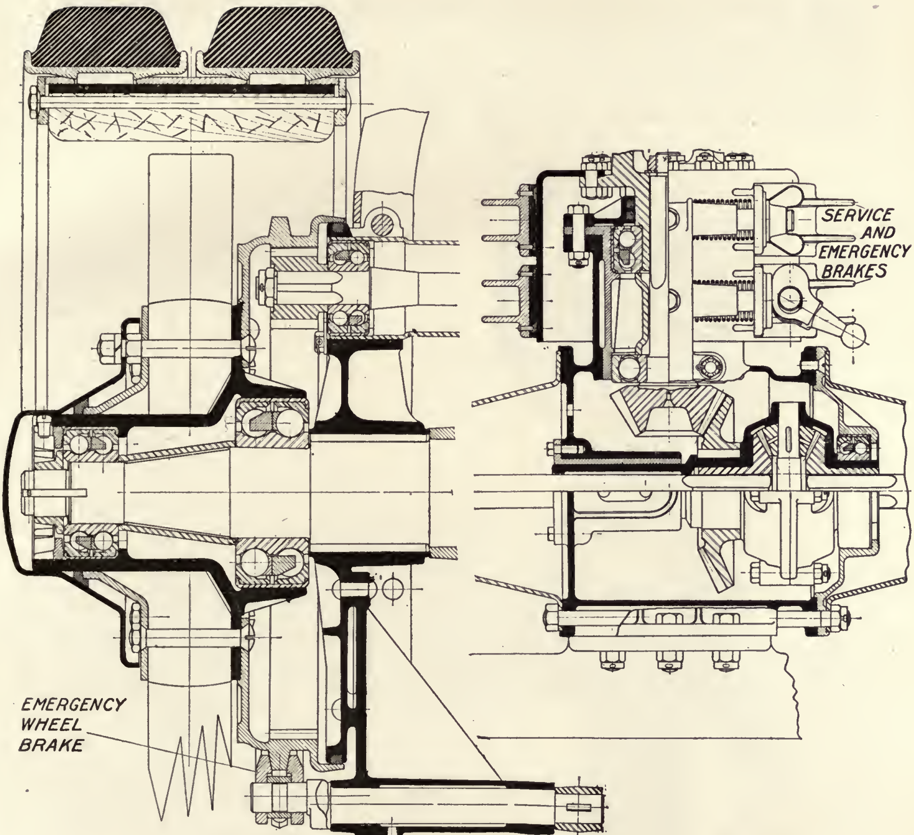

FIG. 124. Studebaker Internal Gear Drive Axle.

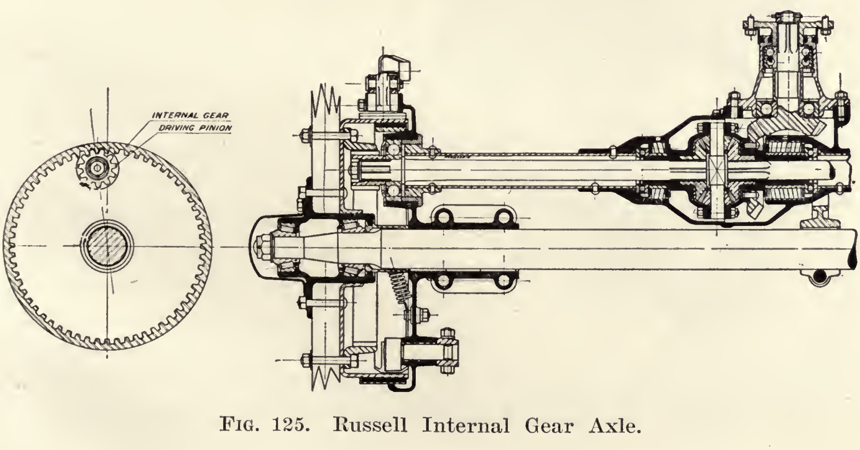

FIG. 125. Russell Internal Gear Axle.

rear wheels themselves in case any breakage should put the regular brakes out of commission.

With this axle, triangular channel shaped pressed members which are bolted to the brake spiders and hinged to a heavy cross member take up the thrust and torque loads.

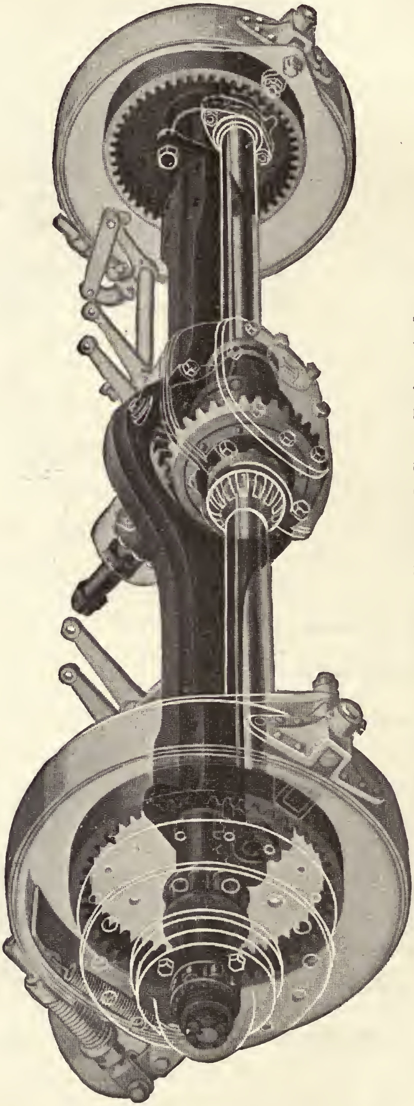

Fig. 126. Torbensen Internal Gear-Drive Axle.

The G. V. Mercedes gasoline trucks are also internal gear driven. While they are similar in some respects to the Studebaker construction, the axle is equipped with only one set of brakes, while the other brake is mounted in back of the transmission. They also use the triangular pressed steel members for taking torque and thrust loads, but have a cross member located directly in front of the jack shaft and bolted to it, and the triangular members.

The Russell internal gear-drive axle illustrated in Fig. 125 has a forged steel dead axle of round section with spring seats keyed to it so the torque and thrust can be taken on the springs. The axle is similar to those mentioned above.

There is one feature about the internal gear in that it employs two reductions as mentioned above and is similar to the chain drive. The first reduction is through bevel gears and is such that a low torque is transmitted by the rapidly revolving drive shafts, which permits a light structure for the driving unit. The next reduction, of course, is near the wheels and supported directly by them. The reduction in the wheels is such as to provide a high torque direct to the wheels. By making the jack shaft a high-speed unit, considerable weight can be saved. However, it has a greater unsprung weight than the chain drive.

The Torbensen axle shown in Fig. 126 is also of the internal gear type. The dead axle is a one-piece drop forging of I-beam section, with chrome vanadium spindles and fixed spring seats. The cylindrical end of the dead axle is of large diameter, and extends nearly to the center line of the spokes, so that the bending moment of the spindle is reduced to a minimum. All members of the jack shaft are enclosed, affording cleanliness, efficient lubrication and quiet working.

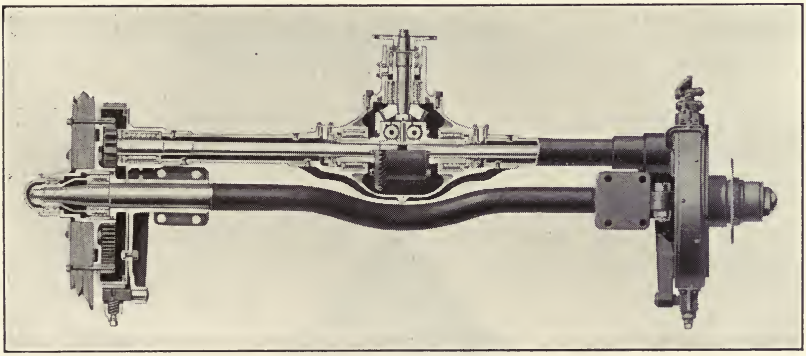

Fig. 127. Clark Internal Gear Driven Rear Axle.

The Clark axle (Fig. 127) is another type of internal gear-drive axle, with a load carrying member of round section. A feature of this axle is that all parts are identical, there being no rights and lefts. The driving unit is located in front of the load carrying member and instead of supporting at the center, the driving unit is supported at each end from the integral spring seats and brake spider. The differential and drive shafts are supported on Hyatt roller bearings and ball thrust bearings, while the wheels are supported on double row ball bearings.

The White 3- and 5-ton trucks are equipped with a combination double reduction and internal gear-drive axle. This axle (Fig. 128), called a double-reduction drive, but in reality an internal gear drive, has a floating rear axle concentric with the axle housing. The power from the propeller shaft is transmitted to the usual bevel gear set and differential which in turn drive the axle shafts. These shafts have spur pinions mounted

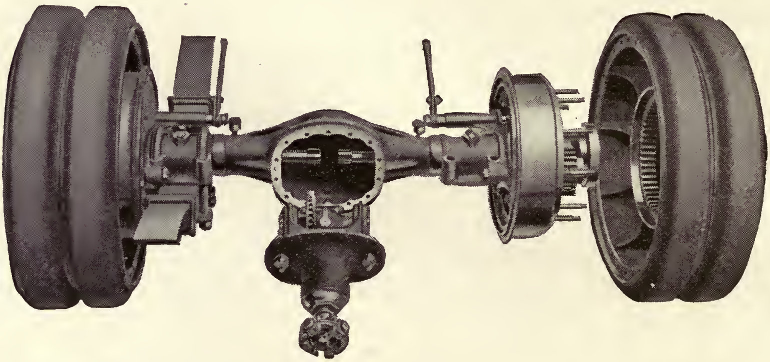

FIG. 128. New Type of Double Reduction and Internal Gear Drive Axle used on White 3 and 4 Ton Trucks.

inside the hub case which mesh with another spur pinion which in turn meshes with the internal gear bolted to the hub of the wheel. By this method of applying the power to the wheel, a

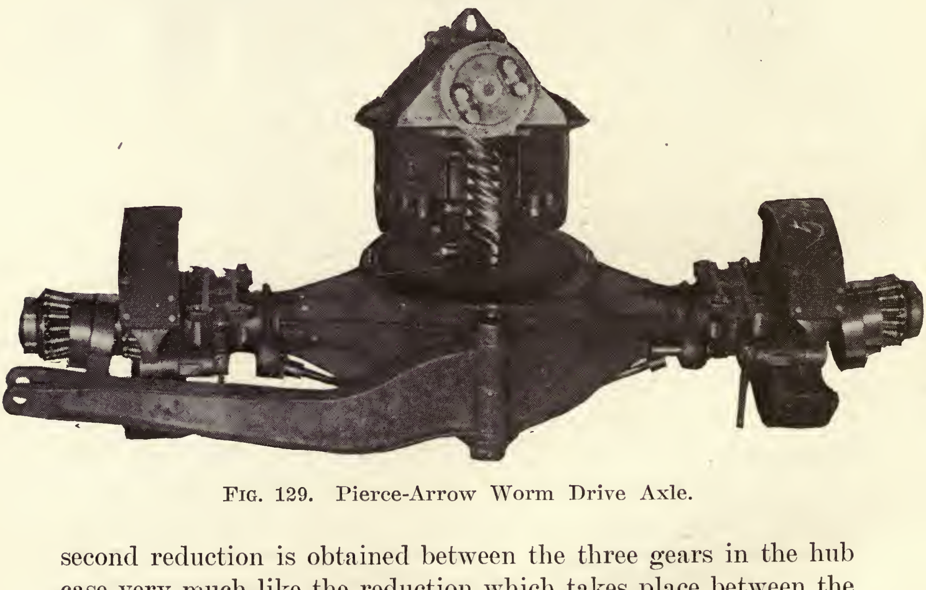

FIG. 129. Pierce-Arrow Worm Drive Axle.

second reduction is obtained between the three gears in the hub case very much like the reduction which takes place between the sprocket wheels of a chain drive.

The Worm Drive.—In spite of bitter opposition, worm drive has made great strides during the past year, quite a number of makers having added worm-driven models to their line, good axles of this type being obtainable. Several of the older companies are building their own axle, amongst these being the Pierce, Packard and Locomobile companies, the former adding a two-ton model, while the latter have recently announced three- and four-ton models.

Fig. 129 will serve to illustrate the Pierce axle which is of the full-floating type, with the worm mounted above the wheel. The worm, worm wheel and spur gear differential are mounted on ball bearings and assembled as a unit with the cover. This construction permits the removal of the entire unit without disturbing the balance of the axle, as shown in the illustration. The housing is a heavy steel casting reinforced by tubes which carry the wheel bearing and extend beyond the spring seats. The emergency brakes are mounted in the rear wheels and the service brake is located back of the transmission. Thrust is taken on radius rods and the torque load on a heavy torque arm. The road wheel is driven through a squared shaft and driving flange bolted to the hub.

The worm-drive axle recently introduced by the Locomobile Company is illustrated in Fig. 130, and is also of the full-floating type. However, it differs from the above in that a bevel-gear

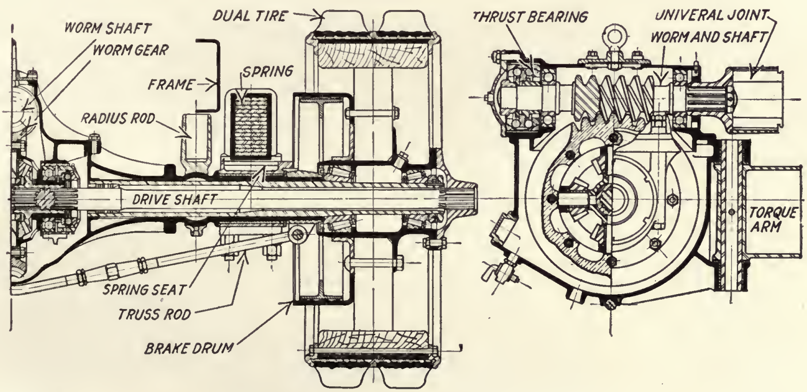

FIG. 130. Riker Worm Drive Axle.

differential is used, while the housing is divided into three parts, consisting of a center housing and two ends which are bolted together. Reinforcing tubes are also used, which carry the wheel bearings and extend to points just outside the differential bearings. The ends of these carry a series of packing washers to prevent the oil working out onto the brakes. The outer ends of the housing have spherical bearings for the radius rods, while the spring seats pivot on bronze bushings. The spring is mounted outside the frame while the radius rods are placed directly under the side frame members. The worm is mounted above the wheel and, together with the differential and bearings, forms a unit with the cover. A heavy truss rod is anchored to the housing

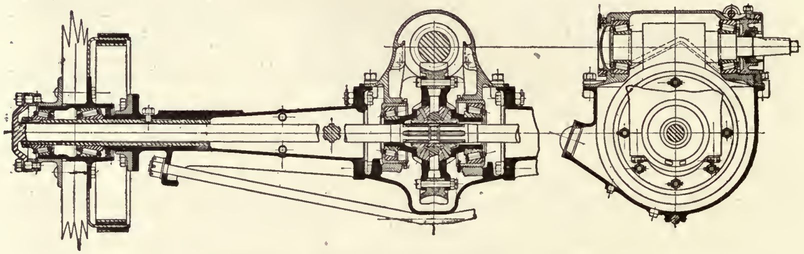

Fig. 131. Timken Worm Drive Axle.

inside the brake drum and provided with a turnbuckle for adjustment. The wheels are mounted on Timken heavy roller bearings, while the driving unit is mounted on ball bearings and provided with suitable thrust bearings. The drive shafts are of the ten-spline type, and drive the wheels through flanges bolted to the wheel hubs. Attention might be called to the method of reducing the weight, by lightening the reinforcing tube. The inner wall of this tube tapers from the end to the center of spring seat, from this point to just inside the inner-wheel bearing where the greatest load comes.

The Timken David Brown axle used in a number of commercial cars is depicted in Fig. 131, being similar in construction to those described above, with the worm, worm wheel, differential and their bearings assembled into a unit with the cover. However, in this axle the well-known Timken bearings are used throughout, and, owing to their ability to carry thrust loads, it is claimed no thrust bearings are necessary. To the writer's knowledge this company is the only one resorting to roller bearings for mounting of the worm. The flange for driving the wheels is forged integral with the drive shaft, while the general construction is along conventional lines.

Another worm-drive axle used by several commercial car builders is the Sheldon axle (Fig. 132). It is also constructed along conventional lines, having the differential and worm gear a unit. However, it is of the semi-floating type, and the housing, which is cast in one piece, is so arranged that either over or underslung springs may be used. As the axle is of the semi-

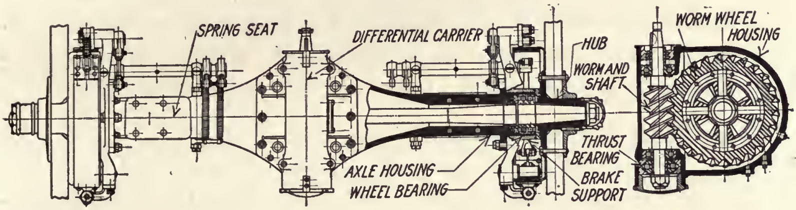

FIG. 132. Sheldon Worm Drive Axle Semi-Floating Type.

floating type, the housing is made of liberal proportion and the weight is carried on the drive shaft, while a ball bearing is mounted inside of the wheel which is attached and driven by means of a long taper and key. This is clearly shown in the illustrations. The features of semi-floating axles can perhaps be best described by comparing with the full-floating and three-quarter-floating types.

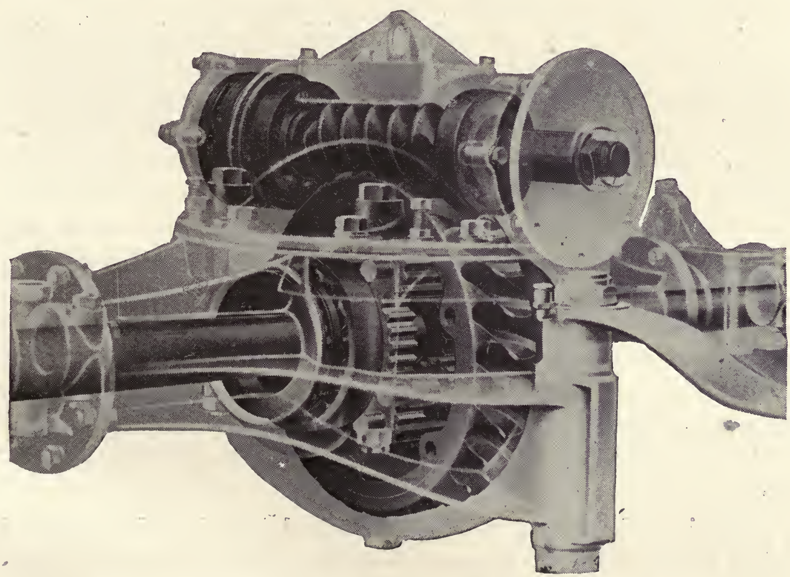

FIG. 133. Phantom View of Packard Worm Drive Axle.

The Packard worm-drive axle (Fig. 133) also has a three-piece housing, with the differential and driving unit mounted in a unit with the cover. The differential is spur-gear type, and the entire driving unit is mounted on ball bearings and provided with suitable thrust bearings. As in the construction described above, the worm is mounted above the wheel. The housing is massive steel construction, well ribbed to provide maximum strength. The entire construction is arranged for straight-line drive from the transmission through two universals, while the thrust is taken by radius rods and the torque by a heavy torque arm.

Rear Axle Types.—Shaft-driven commercial car axles may be classified according to the arrangement of the wheel bearings. If the end of the drive shaft next to the wheel has a bearing directly upon it, the axle is then classed as semi-floating type. This type of axles possesses some advantages in cost of manufacture and simplicity, and is the lightest axle for its strength.

The great strains imposed upon the bearings and housing of the full-floating type in skidding against obstructions are much less in the semi-floating type, because of the greater distance between bearings. However, there is much difference of opinion as to the relative advantages of the various types of axles.

In the semi-floating axle, the drive shaft carries the weight of the vehicle and must also resist torsional strain.

In order to make an axle in which only torsional driving strains are imposed upon the drive shaft—thus approximating some advantages of the dead rear axle—a construction is used wherein each wheel is mounted outside the axle housing, and the drive is taken through a central shaft connected to the hub by either a jaw clutch or flange bolted to the hub. This is known as the full-floating type of axle. It has the advantage of having the axle shaft free from all lateral strains, thus greatly reducing the danger of breakage and of bending, the latter causing the wheel to wabble. Even if the shaft is broken, the wheel is still securely mounted on the axle housing, so that the axle does not drop to the ground. The construction is such that the drive shafts can be withdrawn and even the differential dismounted without removing the wheels from the axle, or the axle from the car.

The jaw clutch for driving the wheel has the advantage of being more easily withdrawn from the axle and affords more freedom to allow for misaligning parts, while the flange drive removes all chances of noise sometimes made by jaw clutches, and is claimed to be sligthly less expensive to construct.

The three-quarter-floating axle is a compromise between the semi-floating and full-floating types. It has the wheel mounted on a single bearing outside the axle housing on a reinforcing tube, and kept in alignment by being rigidly attached to the driving shaft by either a key, as in the semi-floating type, or a flanged connection as in one style of full-floating axle. According to the type of bearing employed at the wheel, the axle shaft is held in place either by the wheel bearing or by some sort of a lock near the differential.

As in most compromises, this type possesses some of the advantages of each of the others. No dead load is placed on the axle shaft, but the skidding strains are little, if any, different on the bearings and shafts than with the semi-floating type. As in the semi-floating axle, any type of bearing can be used, and the weight may be less than the full-floating axle. When the wheel bearings are of a type suitable to take end thrust, they are usually so mounted as to hold the wheel in place on the axle end, and the shaft is connected by a flange. The shaft can then be removed without disturbing the wheel.

Worm and bevel-gear axles are similar to pleasure car axles, and various parts of the other two types are also similar; however, while they are similar, their proportions are materially increased to withstand vibration.

Method of Providing for Torsion and Propulsion in Shaft-driven Commercial Cars.—At the present writing there seem to be about five methods of providing for torque and thrust loads on shaft-driven axles, as follows: (1) torque and thrust through the vehicle springs; (2) torque and thrust through triangular structure attached to a rigid cross member; (3) torque on springs, thrust on radius rods; (4) separate torque and radius rod members; (5) torque tube surrounding drive shaft and anchored to the frame by a large yoke and triangular radius rods anchored to the torque tube.

In a shaft-driven axle there are two separate torsional forces. There is first, the primary torque of the drive shaft, and the secondary torque of the axle itself. The inertia of the axle causes the shaft to react upon the gear set support in a tendency to whirl them instead of itself turning, and the inertia of the wheels on the road tends to cause the axle to whirl, instead of the wheels revolving. Owing to the reduction afforded by the gear set on the lower gears, there is a certain amount of drive-shaft torsion, even on a heavy vehicle. It is no greater, however, the motor being of the same power as in a passenger vehicle, as a rule, and, as in the latter, it can be transmitted directly to the frame, the springs being the medium relied upon to absorb it.

The axle torque offers the greatest problem. In some vehicles the springs or the ordinary form of torque arm supported from the frame have proven successful, while in other cases torsion is provided for by connecting the sub-frame, upon which the complete power plant and transmission system are mounted, to the rear axle at one point and to the forward part of the frame on two points. Propulsion may be through the swinging sub-frame, torque tube, springs or radius rods. When radius rods are used, the springs are shackled at both ends, and when the thrust is taken through the springs the front end is rigidly attached to the frame and the rear end is shackled.

There seems to be a very wide difference of opinion as to the relative merits of the various methods, and examples of each type may be found with either type of axle. The method of taking stresses on the springs, which is termed the Hotchkiss drive, has been quite popular on the lighter vehicles and at the present there seems to be a general tendency to apply it to the heavier vehicles also. The separate torque and radius rod construction is also used on a number of heavy worm-driven vehicles.

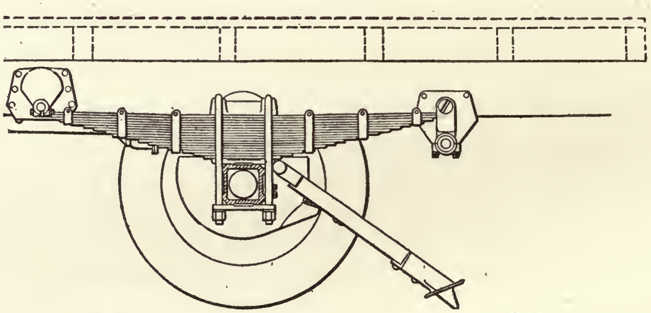

FIG. 134. Arrangement of Springs for Taking Torsion and Thrust. This is called the Hotchkiss Drive.

The internal gear-driven vehicles are divided between Hotchkiss drive and triangular members anchored to the frame cross member for taking up these stresses. The double reduction seems to favor the worm practice, as both of these methods are found, while the bevel drive seems to favor pleasure car methods.

Fig. 134 depicts the spring mounting for Hotchkiss drive, in which both torque and thrust are taken by the springs. The front ends of the springs are rigidly mounted in a heavy bracket attached to the frame, while the rear ends are shackled in the usual manner. The springs must be made with as little camber as possible, that is, the spring should be nearly flat under load, so that the driving effort is applied lengthwise of the top leaf, the direction of the effort lying within the metal instead of across a chord of the arc outside it.

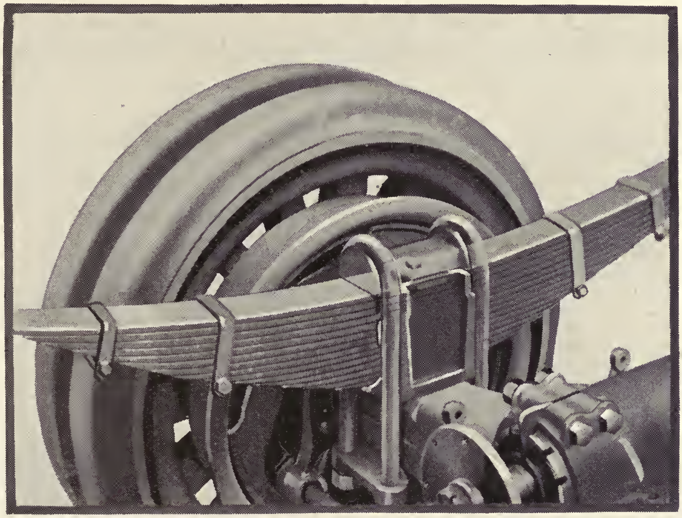

Fig. 135. Diamond T-Spring Anchorage.

Springs for Hotchkiss drive must be especially designed to take these stresses and require numerous rebound clips.

Some excellent features have been developed lately which show how the problems connected with this type of drive have been solved. Nickel steel U-boats are used by many, while others are providing rigid anchoring of the springs to axle in various ways. As flat springs must be used, this necessitates a rigid anchorage to prevent the pressure blocks from creeping.

On the Diamond T-trucks particularly rigid anchoring of the spring to the axle is used. This is shown in Fig. 135, and consists of a special casting which is U-shaped and snugly fits the spring. On top of this casting is a special block, which is recessed to take an upward arch in the center of the top leaf of the spring. On the vertical sides of the U-casting are heavy shoulders

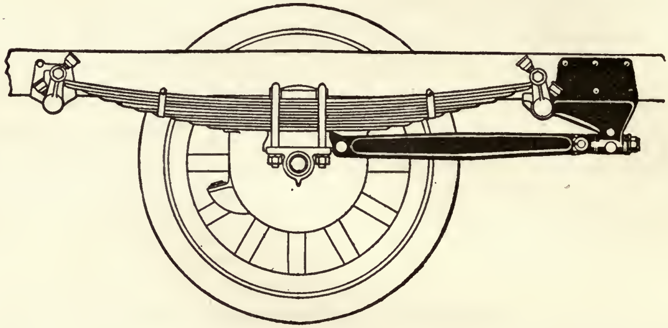

FIG. 136. Torque taken on Springs. Driving Thrust taken on Radius Rods.

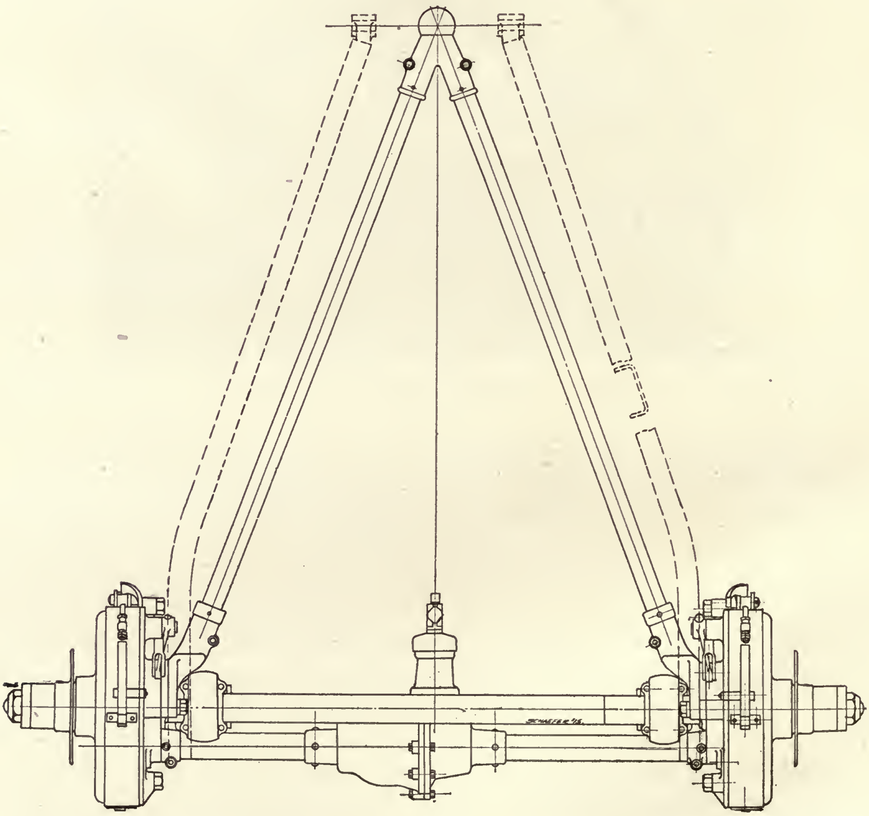

FIG. 137. Triangular Torque and Radius Rods Applied to Internal Gear-Drive Axle.

bearing against the clips or U-bolts and so preventing displacement of these. This feature of keeping the clips at right angles to the spring leaves is an essential of this type of drive. The Winther trucks are provided with a similar arrangement, while on the Military class B trucks the spring plates are provided with spherical depressions which lock the spring plates and prevent creeping.

Those makers who do not provide any special anchorage give special attention to have anchorage as rigid as possible with the use of a specially flat spring with heavy upper leaves. Spring

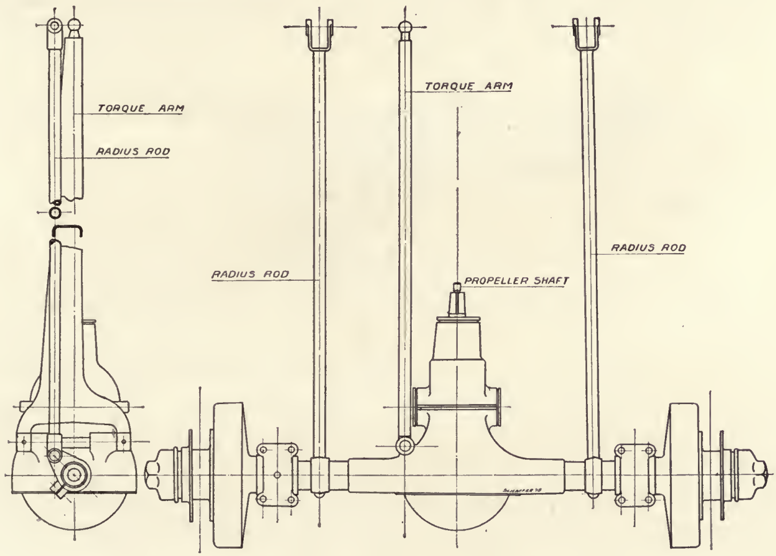

Fig. 138. Separate Torque and Radius Rods.

seats are usually machined to the center of the spring and all points of contact are carefully white-leaded so that both air and water are kept out of the joints.

On the new G. M. C. worm-driver trucks, the springs are shackled at both ends and take the torque load, while radius rods are used to take the driving thrust as shown in Fig. 136.

Fig. 137 illustrates the method of taking these stresses on tubular rods forming a triangular construction with the rear axle. The tubes are rigidly attached to the brake supports at the rear, and form a large ball at the forward end, which is mounted in a spherical bearing on the frame cross member, directly over or under the universal joint. This construction will be found on several internal gear models.

The dotted lines in this illustration show another type of triangular torque and radius rods. However, each rod is hinged separately on each side of the universal joint to the frame cross member. This construction is used on the Studebaker and G.V. internal gear-driven vehicles and the Flint double reduction drive and others.

Separate torque and radius rods are used on the Pierce, Locomobile, Packard and other dorm-driven models, and the Menominee double-reduction drive, the latter being shown in Fig. 138. The torque rod is a pressed-steel channel-shaped member, having a ball end, which is mounted between springs in a bracket hinged to the axle and frame side rails.

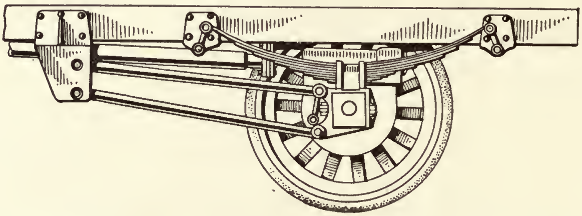

FIG. 139. Manly Method of Taking Drive and Torsional Strains.

On the Manly trucks, the radius rods (Fig. 139) are of peculiar construction and in addition to taking the torque and driving strains also maintain the axle in correct relation to the drive shaft, thus releasing the rear universal joint of any irregularity. Connection from the frame to the axle is made by means of a pair of rods on each side, the rods of one pair being placed above the other and pivoted at both the axle and frame ends. The driving force passes through both rods, being taken from a point under the springs and in line with the axle center to a heavy steel bracket on the frame. The tendency for the axle housing to rotate, which it is a natural result of the reaction of the wheels in driving, is resisted by these pairs of rods. This torque reaction compresses one rod and pulls on the other and because of their pivoted mounting it is impossible to place a binding strain on either rod. The upper and lower rods on each side of the chassis are not quite parallel with each other, their distances apart front and rear, being so proportioned that the rear axle itself is caused to move in a curve that would result from an ideal condition of having radius rods as long as the propeller shaft tube and having their front pivots in line with the front universal. Deflection of the rear universal is thus entirely done away with.

With bevel-drive axles there are several methods in use, which follow pleasure-car practice closely. The torque tube may either surround the drive shaft and the drive be taken through the spring and the radius rod, as in the Commerce, Vim and others, or the torque and thrust may be taken through a torque tube and radius rod hinged to the cross member, as advocated by the G.M.C. 1,500-lb. delivery car, which is illustrated in Fig. 119.

There are various arguments which can be advanced for either of these constructions, while each type seems to have its share of support amongst the manufacturers. From the writer's observations it seems to be the general tendency to let the springs perform these functions in the lighter vehicles, and to use radius and torque rods and combinations of these on the heavier models.

CHAPTER XI

FRONT- AND FOUR-WHEEL DRIVES

In the foregoing chapters on the final drive, we considered all types of final rear wheel drives. There are also a number of commercial cars, in which the final drive is through the front wheels, and others in which it is through all four wheels. Both of these types have gained considerably in popularity of late. This is possibly due, to some extent, to the demands of the various war departments, for motor-driven vehicles, which can propel themselves to any point where mules can pull a wagon.

This same ability is also of great importance in many other classes of service, where departure from the road surface is sometimes necessary. It is especially of importance to coal dealers, who are generally called on to make deliveries in narrow alleys; excavating contractors, who must haul material in and out of excavations, building supply concerns, handling such as lumber, gravel, brick, etc., over unpaved roads and sometimes across swampy land to deliver the material to the building site. There are also other cases to which the four-wheel drive is adaptable.

There is also a variety of cases in which extremely low bodies are necessary, as in hauling long structural girders, timbers and heavy stone. On the other hand, there are such problems as handling light paper, boxed paper and tin cans and tubes and other articles which present a very bulky load. For these purposes, the front-wheel drive lends itself to best advantage, while it is also of considerable advantage for fire apparatus, etc., where it is desired to retain the vehicles used with the horse equipment.

Foreign manufacturers were the first to experiment with these types of vehicles and have perhaps led the way; however, there are a number of companies in America, which are prepared to manufacture these types of vehicles. As the front-wheel and four-wheel drives are closely related, and practically involve the same mechanical problem in driving and steering, they will be considered together.

Four Methods of Drive.—In comparing the various designs we find four methods of driving and two methods of steering. In the first construction, the whole axle pivots about its center and the wheels are driven, as in the ordinary dead or live rear axle. This construction is mostly used with front-drive units, that is, in vehicles propelled through the front wheels only. In the second type, the axles have steering knuckles, as in the conventional type, but the flexibility is obtained through universal joints or chains driving the wheels through internal gearing. In the third type, the wheels are driven through bevel gears mounted inside the wheel and on the steering knuckles, another pair of bevel gears mounted on the steering knuckles driving the wheels, through shafts extending from the central pair of gears in the axle housing. These three are termed mechanical drives; while the fourth construction is a non-mechanical drive, electric motors being mounted in the wheels and driving direct through reduction gearing.

The front-wheel drives, in some cases, are so constructed that this forms the power unit, which may be attached to any type of vehicle the user may desire, while a rear frame construction, upon which any type of body can be mounted, may also be provided. With the latter, the rear wheels may be shod with steel or rubber tires as desired. The Devon, Pull-More, and Meyers may be mentioned as examples of this type.

Whole Front Unit Pivoting Chain Drive.—Referring to Fig. 140, illustrating the Devon Tractor Trailer, the engine is mounted

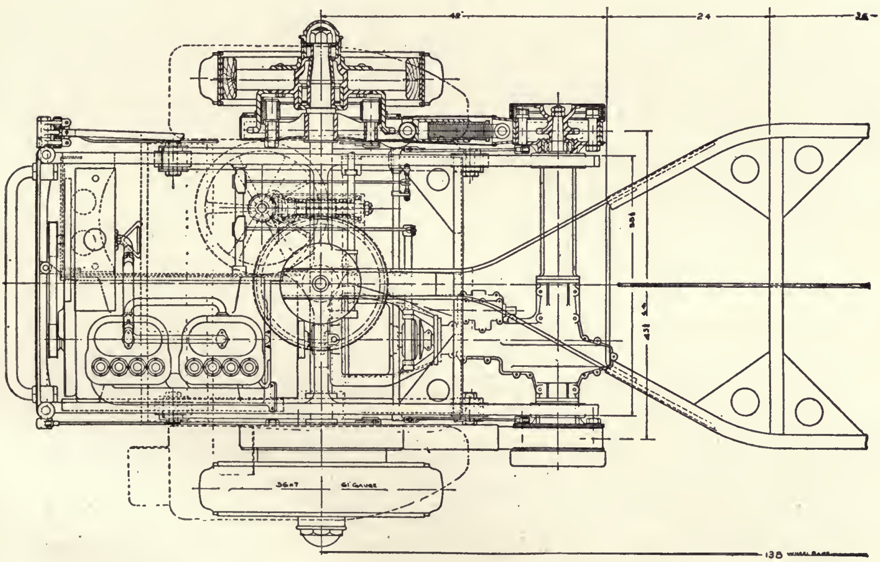

FIG. 140. Plan View of the Devon Tractor.

in front of the axle and placed lengthwise. It is located toward the left side and enclosed by a metal hood. At the rear of this hood is the vertical steering column, and back of this, a metal seat. The power from the engine is transmitted to the clutch and transmission at the rear, the transmission being a unit with a jackshaft, as in the ordinary chain-driven truck. The front axle is similar to the ordinary dead rear axle, and carries a set of brakes and sprockets. From the jackshaft, the power is transmitted to the front wheels through chains, which are enclosed. In steering, the entire unit is turned bodily by means of the steering wheel, through bevel gears, rotates a worm, engaging the cir-

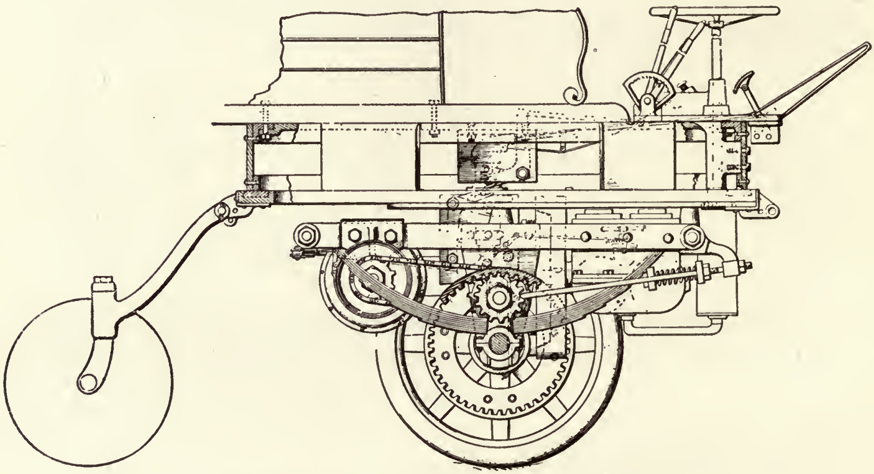

FIG. 141. The Meyers Tractor.

cumference of a large worm wheel attached to the forward part of the main frame and concentric with the pivot. This worm is mounted on a splined shaft, between heavy coil springs to absorb the road shocks.

The Pull-More front drive is similar to the above; but has a power steering device operated by the engine, this steering device working through a sprocket on the crankshaft, which, by means of a chain, drives a countershaft, located in the lower half of the crank case. This countershaft operates the arm of the steering reach, which is a part of the king bolt. This king bolt is located midway between the front wheels, and forms the axis upon which the entire front unit revolves. Differentials are provided to permit right-and-left-hand steering. An ordinary steering post and wheel is used to operate the power steering device.

The Meyers front drive (Fig. 141) is similar to the above types, in that the engine is placed forward of the front axle. The power of the motor is transmitted from the jackshaft, through

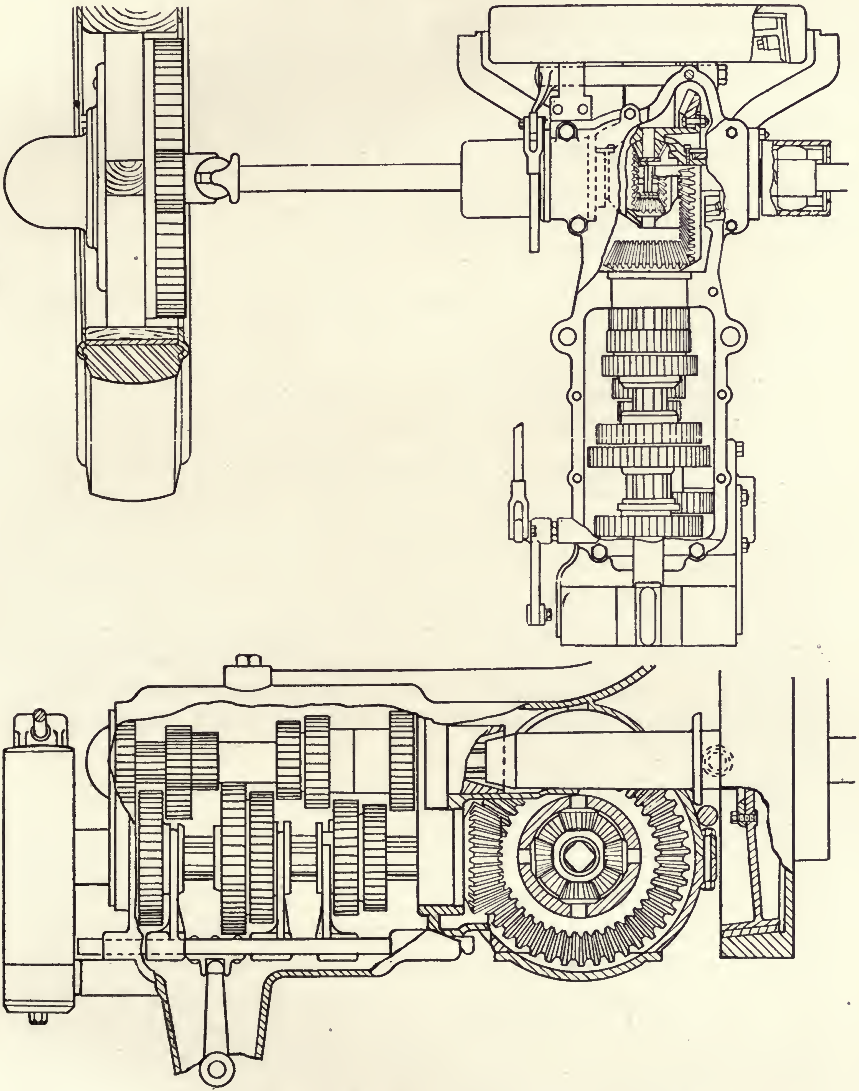

FIG. 142. Side and Plan View of Walter Transmission and Front-Wheel Drive.

side chains, to a shock absorbing bracket, carrying another sprocket attached to a short shaft, on the opposite end of which is a small gear, meshing with a large internal gear, bolted to the spokes of the wheels. The main frame is mounted upon semi-elleptic springs. The upper frame, which forms the pivoting member, has a detachable castor-like wheel and as the weight is to the rear of the unit, it is perfectly stable and can be driven from place to place. The vehicle is steered by means of a circular rack and pinion, upon a fifth wheel. The shock of starting is eliminated by a patented arrangement on the driving pinion. This pinion is mounted on an arm pivoted by the axle and is free to roll in the internal gear to a slight extent, its forward motion being limited by a positive stop and its rearward motion by the rod and spring shown.

Gear Drive.—In the types described above, the power is transmitted to the wheel by means of roller chains. In the Walter truck the power is transmitted by shafts and internal gears, along lines similar to the Latil front-drive trucks, built in France. The transmission of the Walter is mounted with the engine, to form a unit power plant, which is so located that the flywheel is just in front of the front axle, the entire engine overhanging the axle. From the sectional view of the transmission (Fig. 142), it will be noted that the differential and bevel driving gears are mounted at the front end of the secondary shaft, which is placed above the main shaft. From the differential, extends two universally jointed shafts to spur gear pinions on the steering knuckles, which mesh with internal gears bolted to the front wheels. There is no mechanism whatever back of the driver's seat, and the construction is very compact.

Four-wheel Drive.—The layout is such that the front-drive unit does not have to be altered or changed in any way on vehicles, which drive the rear wheels also, the forward unit of the front drive being identical with the front unit of the four-wheel driven vehicle. The secondary shaft of the transmission is extended back to another differential and bevel driving unit, mounted on a frame directly over the rear axle. This unit also has universal jointed shafts, extending to the rear steering knuckles and carrying spur pinions, which mesh with internal gears bolted to the rear wheels.

The rear axle is also used for steering in the four-wheel drive, but not in the front drive.

The conventional type of worm and gear-steering column is used, with a longitudinal cross-shaft, having a universal joint at its forward end. The rear end of this shaft carries a steering arm, which is connected with the usual linkage to the rear wheels, as shown in Fig. 143.

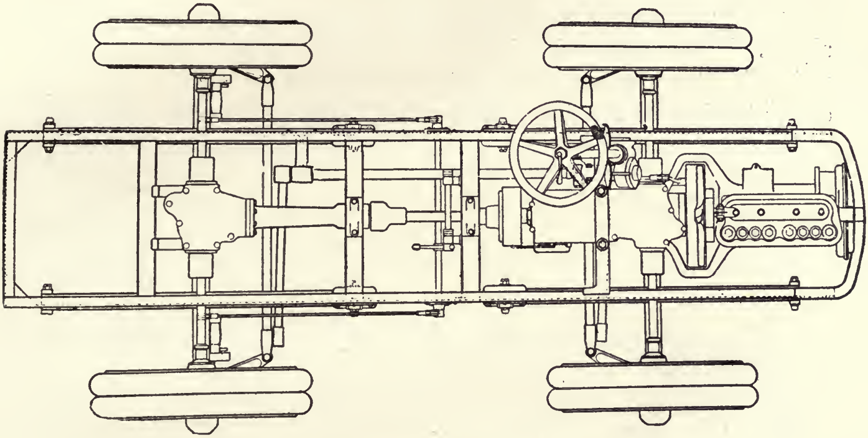

Fig. 143. Plan of the Walter-Four-Wheel Drive Chassis.

The Nash Quad and Duplex four-wheel drive trucks are also driven by means of internal gears and universal-jointed shafts. The wheel construction of the Nash Quad is shown in Fig. 144. The propeller shafts are driven from the secondary shaft of the transmission. The cross-shafts, which drive the wheels, are located above the axle, while the axle carries the weight only and has the driving gear and differential unit bolted to it. The driving pinion meshes with an internal gear, mounted in the wheel. The wheels are cast steel with integral rim, hubs and brake drums. The driving pinion is located above the steering knuckle and driven through a universal joint, the center of which is directly in line with the pivot center of the knuckle.

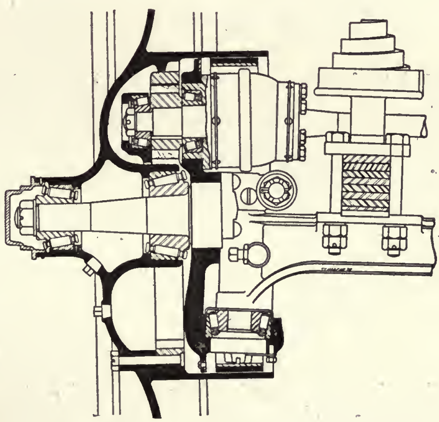

Fig. 144. Nash Quad Method of Driving Four Wheels.

Combined Chain and Shaft Drive.—The Duplex is also driven by means of internal gears in the wheels and universal joints mounted directly over the steering knuckles, and with drive shafts above the springs. However, the method of transmitting the power to the wheels is somewhat different from that described above. The transmission is of conventional design and built in a unit with the engine. Power is transmitted by shaft to a chain case, attached to the frame at approximately its center. This oil-

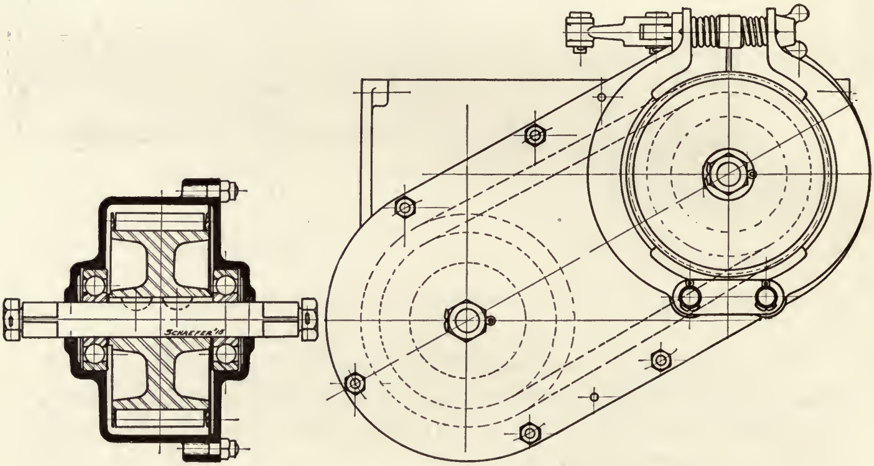

FIG. 145. Duplex Four-Wheel Drive Chain Case.

tight chain case, Fig. 145, is the junction point, connecting the front and rear axle drive shafts, the driving sprocket, by means of a silent chain, delivering power to the sprocket, to which the fore and aft shafts are attached. The shaft, on which the driving sprocket is mounted, carries a brake drum, which forms the service brake, acting on all four wheels. Emergency brakes are on the rear wheels. The vehicle is steered by the front wheels only, in the usual manner.

Live-axle Drives.—Another type of four-wheel drive construction is that employing a live front and rear axle; that is, an axle which both propels the car and carries the weight of the vehicle and load. The F.W.D. and Nevada trucks are of this type.

In the F.W.D. chassis, the transmission is centrally located with a very broad, silent chain, which transmits the power to a shaft parallel to and far enough to one side of the transmission to permit proper clearance between the engine and propeller shaft. Each of the two propeller shafts carries a brake drum, so that the braking force is applied to all four wheels. Steering is by the front wheels only, so that the rear axle is of conventional full-floating design with bevel-gear drive, excepting that the differential housing is located to the left of the axle center.

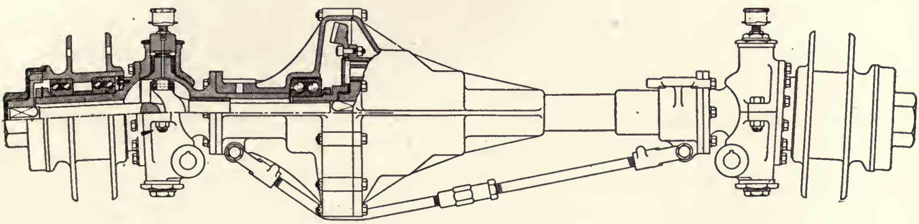

FIG. 146. F.W.D. Front Axle.

The steering-knuckle pivot of the front axle (Fig. 146) is in the form of a spherical joint, which has two trunnions, one on the upper side and one on the lower side, so that only a pivoting action, instead of a universal action is obtained. A divided housing surrounds these joints, to which is bolted the spindle, upon which the wheel revolves. This pivot and wheel spindle are hol-

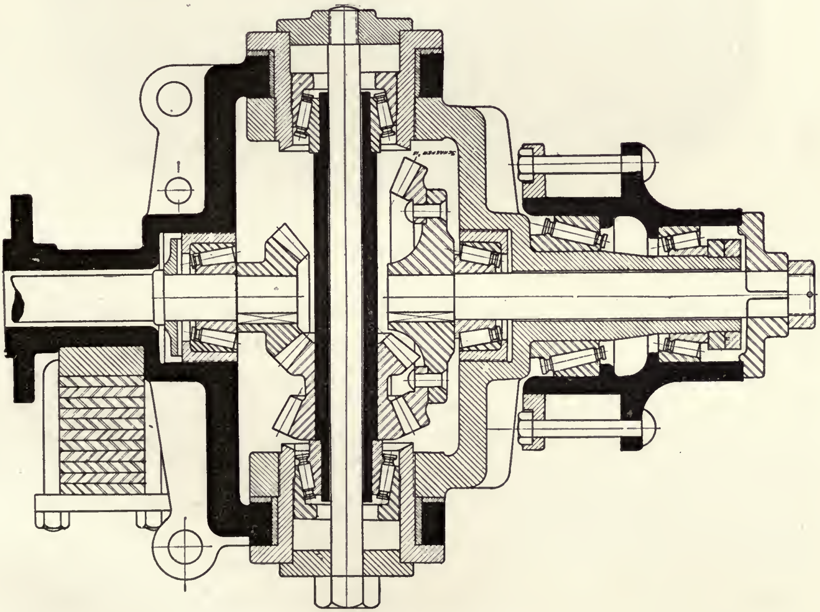

FIG. 147. Nevada Front Wheel Drive.

low and contain the drive shaft and universal joint. The center of this universal is in line with the center of the wheel pivot and the shaft from one end extends into the differential, while the other end has a square, which fits into the flange that drives the wheel.

In the Nevada, the steering is also by front wheels only. The general application of the power to the front wheels differs somewhat from the above, although this design also employs full-floating axles. In this vehicle, the differential in the axles is located to the left of the center and the front axle has a somewhat different power-transmitting device in the steering knuckle.

The steering knuckles (Fig. 147) are similar to the usual type, consisting of a yoke at the end of the axle tube, through which passes a king bolt, on which revolves a solid wheel spindle. On the knuckle, which surrounds the king bolt, is revolvably dis-

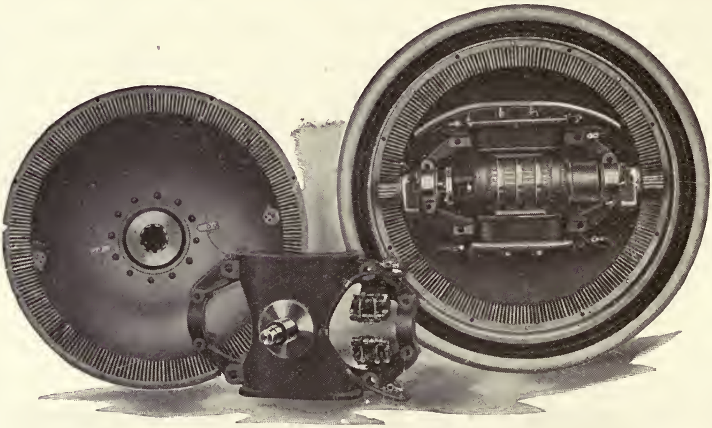

Fig. 148. Couple Gear Electric Drive.

posed a double bevel pinion. The lower teeth of this bevel pinion are engaged by a bevel at the end of the axle shaft, which is disposed within the axle tube. The upper teeth mesh with a larger bevel gear, this being fastened to a stub shaft extending through the wheel to the outer edge of the hub. The end is squared and engages the driving flange, which drives the wheel.

In the chain-driven vehicles, the thrust and torque are taken by the conventional radius rods, while the remainder are divided between spring and radius rod construction. This is also true of differentials, as some use three and others two, in compensating for the division of power between the wheels.

Electric Drive.—The fourth type, or electric, is particularly adaptable to one, two or four-wheel drives, and affords a very simple construction mechanically. The Couple Gear Freight Wheel Company makes a type of road wheel, which is constructed from two steel discs, between which is mounted an electric motor. This wheel (Fig. 148) can be attached to an axle, regardless of whether or not it is pivoted. This company builds two types of trucks, one straight electric and the other gasoline electric. In the former, batteries are used to supply the current to the motors in the wheels, while in the latter type, a gasoline engine drives an electric generator, which furnishes the current consumed by the motors, in driving the wheels. The motor is carried by the steering knuckle, the armature having a pinion at each end, one pinion pulling up on one side and the other pulling down on the opposite side and both mesh with large ring gears attached to the two discs of the wheel. This affords a single reduction of twenty-five to one. A device, which is termed an "evener," permits of compensating movements and divides the force equally between the two pinions, regardless of any unequal wear or adjustments.

Both front-wheel drives and four-wheel drives are capable of further developments, and, if demands for these types of vehicles continue, we may expect to see considerable improvement in details.

CHAPTER XII

MOTOR TRUCK BRAKES

From what has been said of the brakes in discussing the final drive and the various methods of applying the power to the road wheels, it can readily be understood that there would be little uniformity as regards brake construction and location, except that all states have laws which specify that vehicles must be equipped with two-brake systems—one system for ordinary service and one for emergency. In horse-drawn vehicles, the brakes are applied directly to the steel tires; however, since rubber is quite expensive, this method of brake application is not commercially possible; but it is effectively accomplished by securing to the wheels a metal drum, on which the friction members act.

Until recently more attention has been given to acceleration of the commercial car than to the retarding forces at the driver's disposal. This subject at present is receiving considerable study, which is evident by the variety of types and the numerous locations. The brakes are invariably applied to the rear wheels, as they present considerable advantage, supporting the greatest portion of the vehicle and load.

On vehicles employing the double side-chain drive, it has been considered good practice to place one set of brakes on the jackshaft and one set in the rear wheels. There are various positions for this brake, either inside or outside of the frame. This type of brake can be made light and powerful, but possesses other disadvantages which have led some makers to place both brakes in the rear wheels. On shaft-driven vehicles, one brake can be mounted either at the front or rear end of the propeller shaft and one set in the wheels, or both sets may be placed in the wheel drums.

Locations.—Rear-wheel brakes for either type of final drive may be divided into three general arrangements, viz., two internal brakes on the same drum, one internal and one external brake on the same drum and one external and one internal or two internal brakes operating on concentric drums.

Types.—There are two general types of brakes—the band and shoe types, and either may be made external contracting or internal expanding. The band type consists of a continuous steel band having a fabric frictional facing, while the shoe type may either be of cast iron with a high percentage of manganese, of phosphor bronze with cork inserts, or provided with a fabric facing.

When frictional facings are not used, the shoes are provided with diagonal grooves to prevent chattering and squeaking. Each type presents a variety of constructions, as regards anchorage, adjustments, and operating mechanism. In addition to the brakes acting on the rear wheels, the Saurer motor brake can also be mentioned.

The writer, in discussing this subject, will endeavor to cover the principal types in use and in conclusion outline their advantages and disadvantages.

Considering first the chain-driven vehicles, we find two locations for the service brake, either outside or inside of the frame.

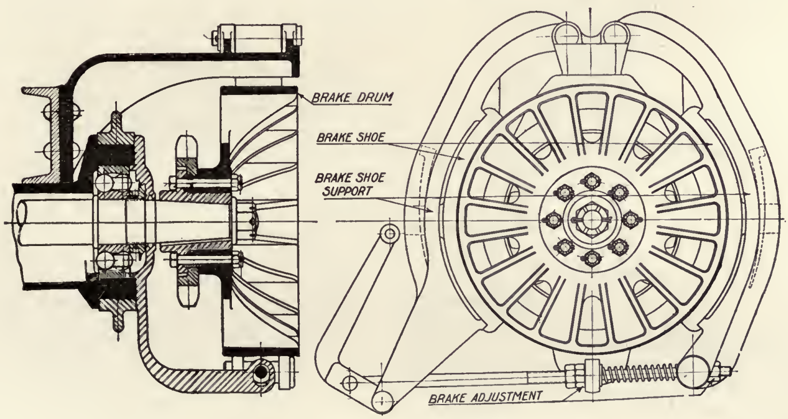

Fig. 149. Knox Jack Shaft Brake.

Jackshaft Brakes.—Fig. 149 serves to illustrate the jackshaft brake used on the Knox tractor. This is of the shoe type mounted outside of the frame and is anchored to the frame side rail by heavy brackets. Like all jackshaft brakes, this is of the high-speed type and equipped with two cast iron brake shoes, which are easily removed for renewal and mounted on large supports, while ample adjustment is provided through the rod connecting the two shoe supports with the operating lever. The brake drum is made from cast steel and is fourteen inches in diameter with four-inch face. It is attached to a hub which also carries the driving sprocket. Features worthy of attention in connection with this construction are the particular attention paid to the strength of the brake anchorage and the unusual provision for cooling presented by the twenty ribs on the brake drum.

Hydraulic Rear-wheels Brakes.—The rear-wheel brakes are perhaps the largest ever attempted and are 20 ins. in diameter with a $6\frac{1}{2}$-in. face. They consist of steel shoes lined with friction fabric and hydraulicallly operated. This hydraulic mechanism is of ingenious design, so that there is practically no difference in their operation from the ordinary hand brakes. A pump lever takes the place of the ordinary hand lever and a button for the release of the brake. To apply the brakes, the operator makes two or three full strokes with the handle forward and backward and the application of the brake will then be felt in the form of a resistance pulling the lever backwards, the same as with the hand lever. After the resistance is felt a good hard pull on the handle will lock the rear wheels. The release is accomplished by push-

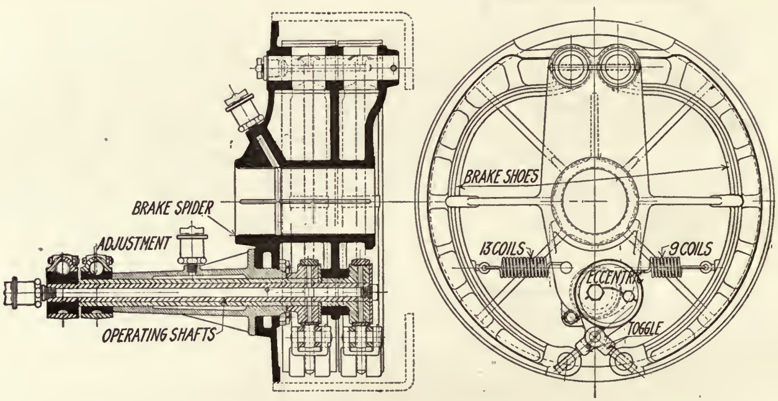

Fig. 150. Kelley Internal Expanding Rear Wheel Brake.

ing the button on the top of the handle and pushing the handle forward beyond the stop normally interposed. Passing beyond this stop exposes a release part in the pump, which allows the liquid to flow back through the pump into the reservoir.

Most any of the following brake constructions can be applied to the jackshaft, while they may be placed either outside of the sprocket, between sprocket and frame and as mentioned previously inside of the frame.

Rear-wheel Brakes on Chain-drive Models.—When both brakes are located in the rear wheels, they are generally of the internal expanding type. The reason for this is, should an external brake become disarranged, the chain and other parts may be injured, due to the brake mechanism being caught in the chain or sprocket.

The Kelly and Natco trucks are examples of this type. The Kelly brake construction, shown in Fig. 150, presents an excellent arrangement and possesses several features. These brakes are of the shoe type, located side by side, lined with a friction fabric,

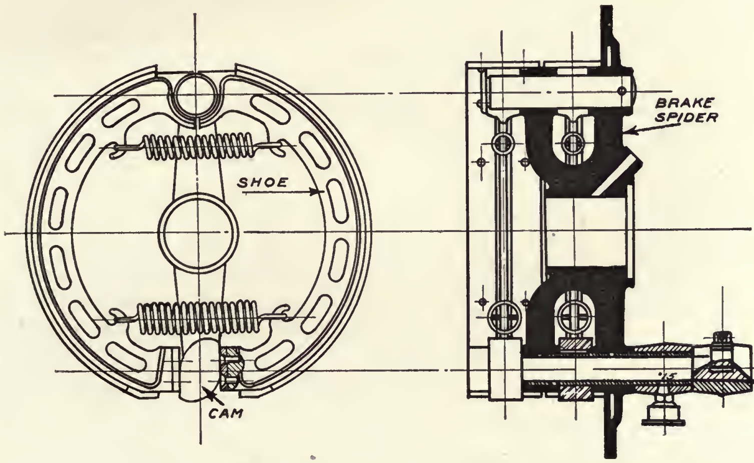

Fig. 151. Natco Double Rear Wheel Brake.

and operated by a combination toggle and eccentric. Each set of shoes are hinged on liberal eyed pins and anchored to the brake spider, which is attached to the radius rod. A toggle action, operated by an eccentric or cam, expands the front end of the shoes, while the tubular shafts, operating the eccentrics, extend through the brake spider flange extensions and are keyed at the outer ends of the worm-wheel operating levers. This feature places the brake adjustment outside of the wheel so that adjustment can be obtained without removing the wheels. Another feature is the provision of large grease cups and liberal grooves for lubricating the various shaft bearings.

The Nacto Brakes (Fig. 151) are also of the lined-shoe type; however, they differ from the above in that they are cam actuated and have their adjustment incorporated in the brake linkage. Each pair of shoes is hinged to the spider at one end, while the other end carries hardened steel plates, against which the cam bears in expanding the shoes. The shoes are not rigidly attached to the hinge pins, but are free to move and, in applying the brake, the forward end engages the drum first, so that this free end permits the shoe to engage more evenly at all points of its circumference.

Brakes on Shaft-drive Models.—The two brake locations in the shaft-drive vehicle are on the propeller shaft and rear wheels, or both in the rear wheels. This applies to either bevel, double reduction, internal gear, or worm drive, the bevel and double reduction axles universally using the double rear-wheel brake.

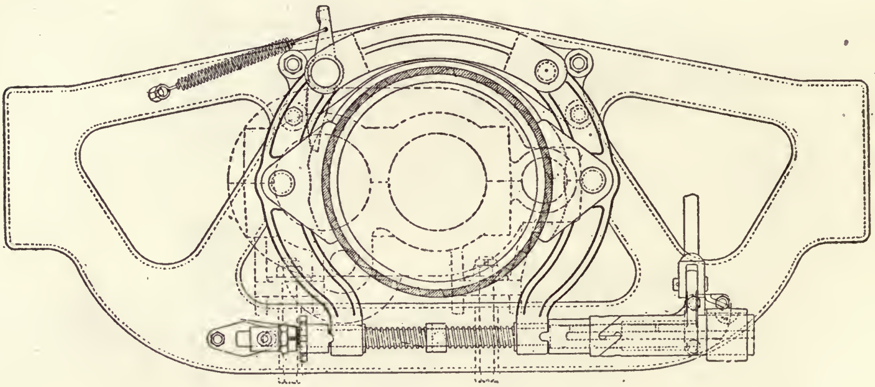

FIG. 152. Pierce-Arrow Propeller Shaft Brake.

Propeller-shaft Brake.—The Pierce-Arrow worm-drive trucks offer an excellent example of the propeller shaft brake. This brake (Fig. 152) is located immediately back of the transmission and anchored to a frame cross member. In this type, two cast-iron shoes are brought to bear against the cast steel brake drum. These shoes are hinged to arms on each side of the drums, these arms in turn are hinged to a bracket, which is attached to the bottom of the cross member, the top ends pivoting on the operating shaft. Springs are placed on the operating shaft, between these two arms, to keep the brake released. Mounted on the operating shaft, is a ratchet, which is prevented from turning by a tongue fitting into a groove in one arm. The brake lever has an integral ratchet, which meshes with the ratchet mounted on the operating shaft, forming a means of applying the brake. A nut is placed at the other end of the operating shaft, forming the brake adjustment. The drum has an integral ratchet, and a pawl lever is attached to the lower link, being held erect, out of engagement by a spring. This forms a ratchet type of sprag for locking the wheels on steep hills and removes the strain from the brakes.

The Packard worm drive and G.V. internal gear-drive trucks also employ the transmission brake, while the Mais, Fremont-Mais and $3\frac{1}{2}$-ton Republic internal gear-driven trucks have the service brake mounted on the pinion shaft and anchored to the axle housing.

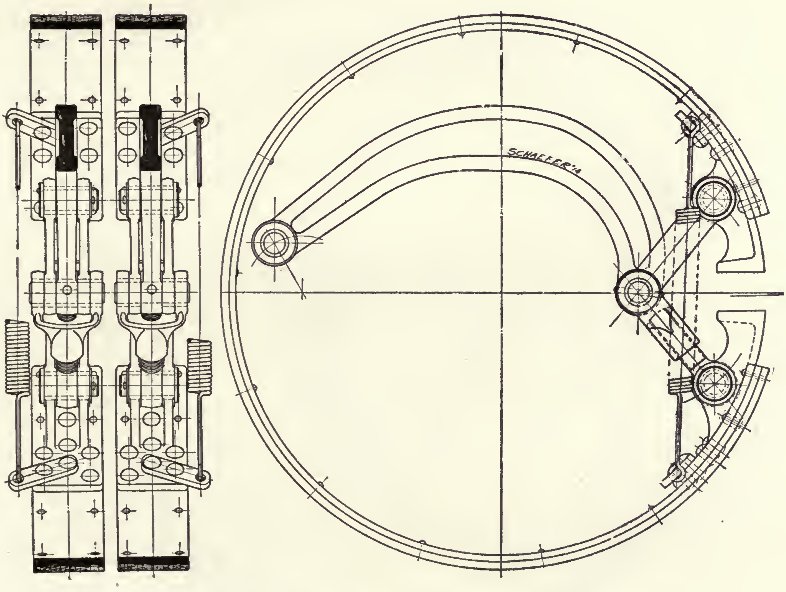

FIG. 153. The Sheldon Internal Expanding Brake.

Band Brake.—The Sheldon brake (Fig. 153) illustrates a simple band brake, sometimes called a single expanding shoe, operated by a toggle linkage. This type of brake is used on this company's worm-drive axles, being located side by side in the rear-wheel drums. The bands are supported by three brackets bolted to the brake spider, which carries the operating levers and shafts. The bands are expanded through small links attached to brackets riveted to them and a long link attached to the lever on the operating shaft. A large stud, located in the spider, prevents them from rotating. A coil spring releases the bands and holds the brackets in contact with the stud. Adjustment is made through the brake linkage and one of the toggle links.

Internal and External Brakes.—The Clark Equipment Company offer an excellent example of internal and external rear-wheel brake (Fig. 154) in the construction employed on its internal gear-driven axles. The external brake is anchored to one end of the brake spider while the other end is provided with a simple adjustment for taking up the wear of the lining. The internal brake band is also lined with a friction fabric and expanded by a cam. This cam operates on hardened steel plates, set into the

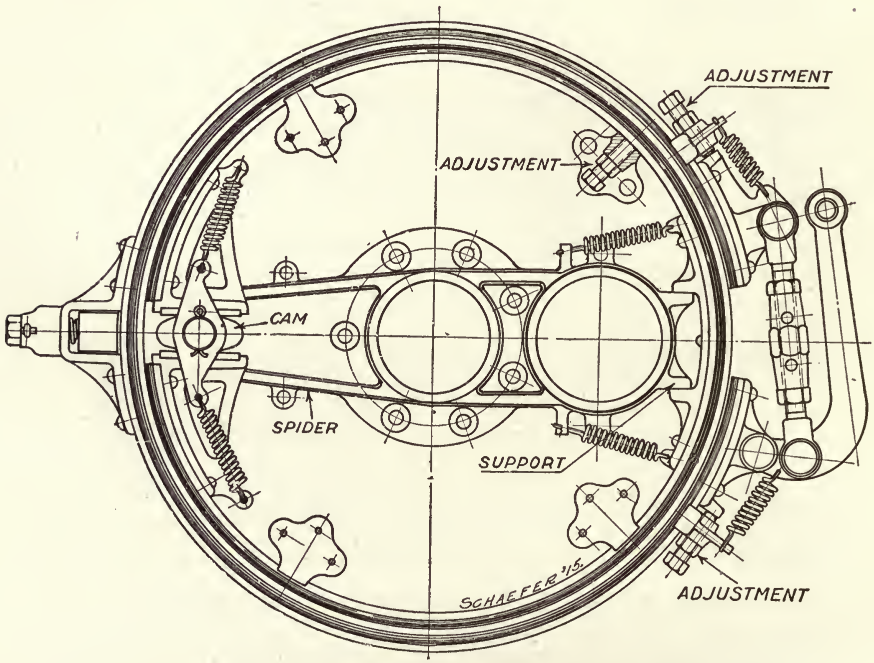

Fig. 154. Clark Internal and External Brakes.

brake band brackets and so arranged that they can easily be renewed. The forward end of the brake is supported by an extension of the brake spider and has liberal provisions for adjustment.

An excellent feature in connection with this brake is the provision of a metal disc and packing separating the gear compartment from that of the internal brake. This, in addition to making it possible to lubricate the gears with graphite, guards against the breakage of the gears in case any part of the brake mechanism should come loose.

Another good example of internal and external brake construction is shown in Fig. 155 and used on the Autocar. The external brakes are of the double shoe type, fabric-lined and hinged to a stud projecting from the brake spider, and small clevises, attached to the spider, hold the shoes longitudinally on the drum. They are connected at the front end by a rod, which forms the adjustment and also carries the springs to release the brake. The

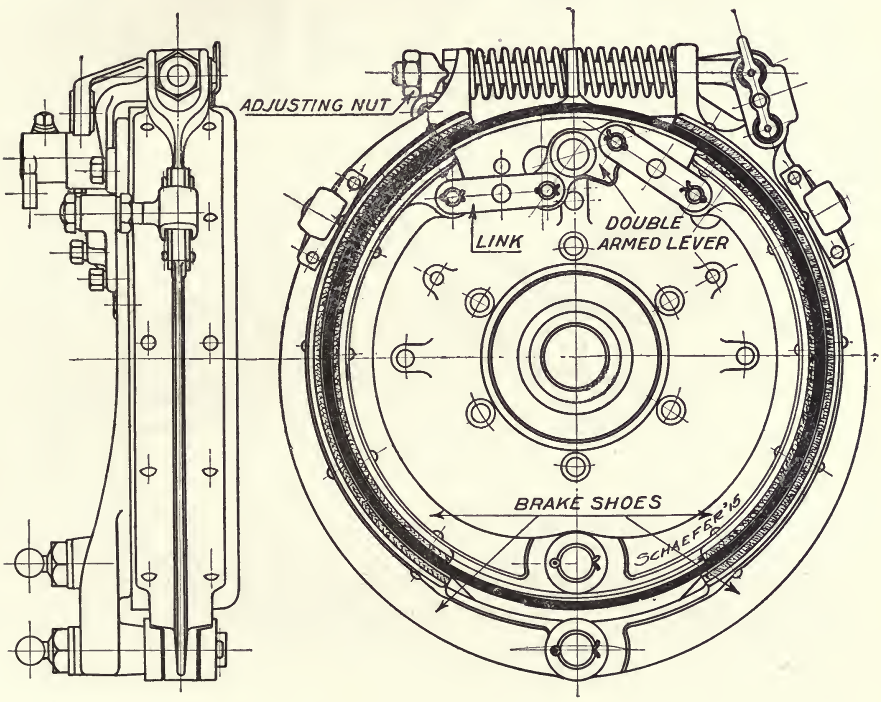

Fig. 155. Autocar Internal and External Brakes.

internal brakes are also of the shoe type, fabric-lined and hinged to the brake spider. They are expanded by a double-armed lever which is connected to them by links. This lever is similar to a bell crank, with pins extending laterally from the ends of its arms, to which the links are attached.

Concentric Brakes.—The G.M.C. construction, Fig. 156, depicts a type employing concentric drums. The internal brake is of the conventional shoe type, fabric-lined, expanded by a cam and operating on the inner drum. The external brake operates on the outer drum, being of the band type and contracted by a double-armed lever. This double-armed lever is formed integral with the operating shaft and is slotted to receive the band bracket and the clevis rod, which carries the releasing spring and also forms the adjustment.

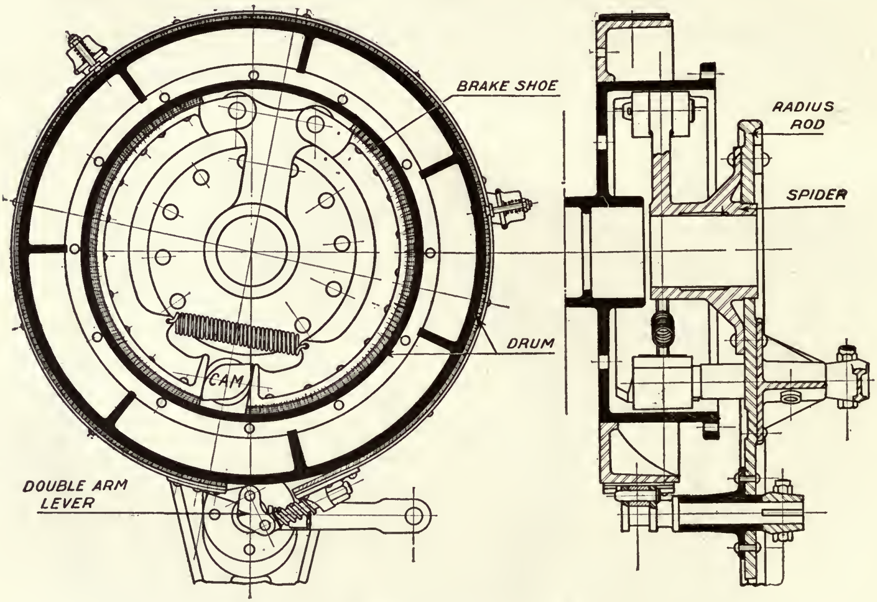

FIG. 156. G.M.C. Concentric Brakes.

The Timken Duplex Brake.—The Timken Detroit Axle Company has recently introduced a new type of brake (Fig. 157) on its worm-drive axles, which is termed a "duplex brake." These brakes consist of four fabric-lined shoes, located in such a manner that the pair of brakes takes up but little more room than a single brake of ordinary shoe type. These four shoes are equally spaced on the inner circumference of the brake drum and each pair located diametrically opposite are expanded by cams and supported by the brake spider and large pins. One pair of shoes has single arms, which extend to the cam and its support and these pass between two arms of the other pair of shoes. These shoes are made somewhat larger in width, to obtain the proper brake area and are held longitudinally, by means of hardened steel washers on the operating shaft and by the brake spider.

Any one of the brakes described above, with the exception of the Pierce and Knox, may be applied to a chain- or shaft-driven vehicle in any position mentioned.

Saurer Motor Brake.—Another type worth mentioning is the Saurer brake, being an air brake worked by the the throttle lever. For a quarter of a circle this lever controls the throttle, but beyond this position, through a device incorporated in the carburetor, it causes the motor to operate on the two-cycle principle, compressing air in the cylinders to an extent which enables the car to be controlled on a 20 per cent. grade without the need of a brake.

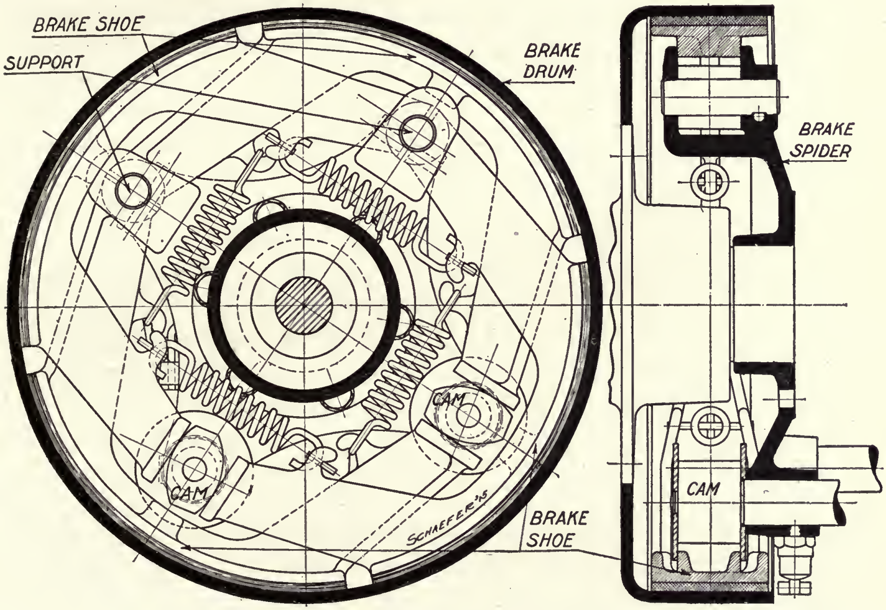

FIG. 157. Timken Duplex Brake.

In applying any type of brake, it must be held from rotating and this strain is generally taken by the brake spider which rides free on the axle or jackshaft and transmits this strain to the radius rod or frame on the chain-driven vehicles and to the axle housing on shaft-driven vehicles.

Mounting the service brake on the jackshaft or propeller shaft places these brakes where they are well protected and, as they are of the high-speed type, the reduction through the chains or gearing makes them more powerful. This presents a disadvantage, in throwing the entire braking strain on the chains or drive shaft and differential and thus shortening their lives. Should the chains or drive shaft break on a bad hill, and the emergency brakes be out of commission, serious damage would result. Although this may rarely occur, some makers have protected their vehicles against such accidents, by placing both sets of brakes in the rear wheels, thus placing the retarding force as near as possible to the point where the momentum of the vehicle is checked. In a sense, this argument is true, especially on the heavier vehicles, for the fewer elements there are between the tire and brake, the fewer are subjected to stress and the fewer are the chances of failure.

Brake adjustments are also receiving considerable study and, while in some cases they are almost hidden, in others they are very accessible. This adjustment may either be incorporated in the brake linkage or in the brake. The tendency seems to be toward locating it in the brake in such a manner that it is accessible without removing the wheel.

Brake equalizers are quite common on commercial cars, the well-known whippletree type being quite popular.

When a single brake is applied on the propeller shaft, the differential takes care of the distribution of force to the two wheels equally, but this kind of compensation has a disadvantage, in that, if the adhesion of the two wheels is greatly different, that with the slightest grip on the road may actually cause it to rotate backwards. Still, it is only on very rare occasions that this reverse motion occurs and it is not, therefore, a cause of much added tire wear.

If the braking forces are not equalized, the task of adjusting the brakes is much more difficult than it need be. On one vehicle, the whippletree equalizer is replaced by a diminutive differential gear, providing a smoother action and a much larger range of equalization.

CHAPTER XIII

THE FRONT AXLE

The front axle with its steering gear, knuckle and arms is largely depended upon for the safe control of the vehicle, while it must also carry the forward portion of the vehicle and load. It must be so arranged as to permit steering the car and in order to accomplish this, the front wheel spindles are pivoted in the axle end and are held in proper relation to each other by a tie rod, which connects levers extending from each pivot. Another lever extends from either right or left-hand pivot (depending upon left or right-side drive) which is connected by a drag link with the steering gear.

This pivot is termed the steering knuckle and has the wheel spindle formed integral, while the levers may either be formed integral, or attached to the knuckle.

Three General Types.—There are three general types of steering knuckles, known as the Elliot, Reversed Elliot and Lemoine types. In American practice the Elliot type is most extensively used and the Lemoine least. In the Elliot type the ends of the axle proper are forked and the steering knuckle is T-shaped, while in the reversed Elliot the knuckle is forked and the axle end forms a T. In the Lemoine type both axle end and knuckle form L's. In practice each of these types differ somewhat, depending upon the type of bearings and the method of mounting the knuckle in the axle end.

For some time it was the general impression that when the plane of the front wheel was in line with the plane of the knuckle pivot, the effect of road inequalities would not be transmitted to the steering gear. This contention led to the introduction of a type of knuckle in which the wheel center lies very close to the pivot center.

The knuckle in this type, instead of having a T-shape, includes a sort of a yoke extending outside of the wheel hub to points close to the spokes and the forked axle ends are pivoted to the yokes at these points. However, this is of minor importance, since the speed of commercial cars is comparatively low and with a semi-reversible gear the road shocks are not transmitted to the steering wheel. One prominent maker employed this type of knuckle for a number of years, but has discarded it and is now using the Elliot type.

The levers to which are attached the tie rod used for connecting the two knuckles and the one for connection with the steering gear are known as knuckle arms. These may either be formed integral with the knuckles, or attached by means of a taper and keyway, retained by a castellated nut. One prominent maker forms the spindle and levers separately so that they may be dovetailed together and retained by the pivot pin. The general practice is to attach them to the knuckles since this simplifies manufacturing and replacement.

Owing to their importance, the knuckles and arms are always forged from a good quality of steel and heat treated. The tie rod may either be placed in front or in the rear of the axle, while the steering connection may either be arranged for cross or fore and aft steering. The arrangement of tie rod and steering connections depend upon the general construction of the vehicle and the location of the steering gear.

The Axle Proper.—The axle proper may either be forged from medium carbon steel of solid rectangular section or of I-beam section, approaching a full rectangular section. Cast steel axles are also used, while one maker of a popular priced vehicle uses cast steel ends with a round section center. These axles may also be built up with tubular centers, flat plates riveted together, or from pressed steel of channel section.

Attachment to Frame.—In conventional designs the only connection between the axle and the frame is through the front springs, which with few exceptions are of the semi-elliptic type. One maker uses a full elliptic front spring and provides a distance rod to hold the axle in alignment with the frame.

Fig. 158 illustrates a front axle with cast steel center for light delivery cars of 750 to 1,000 lbs. capacity. The center is dropped considerably, that is, the topmost surface of the axle bed is located considerably below the center of the wheel spindle, since it is intended for use with full elliptic front springs and pneumatic tires. The knuckle is of the Elliot type and drop-forged with integral spindle and has a boss at its lower end which is provided with taper and keyway for attaching the knuckle arm. The tie rod is placed to the rear of the axle center and is attached to the knuckle arms by a clevis and bolt. The knuckles are arranged for cross steering and one clevis bolt has an extension which carries a cross to which the drag link is attached. This cross serves as a universal coupling to compensate for the angular positions of the

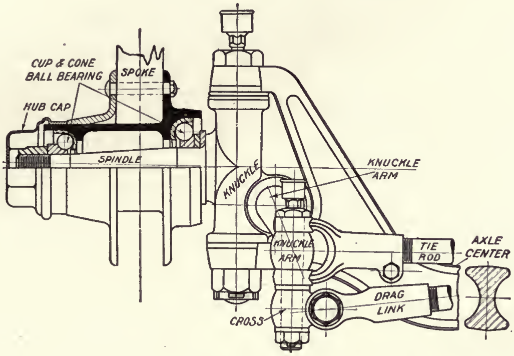

FIG. 158. Light Truck Axle with Cast Center.

knuckle arms and the variation in the vertical movement between axle and frame. This is necessary as the steering gear is always

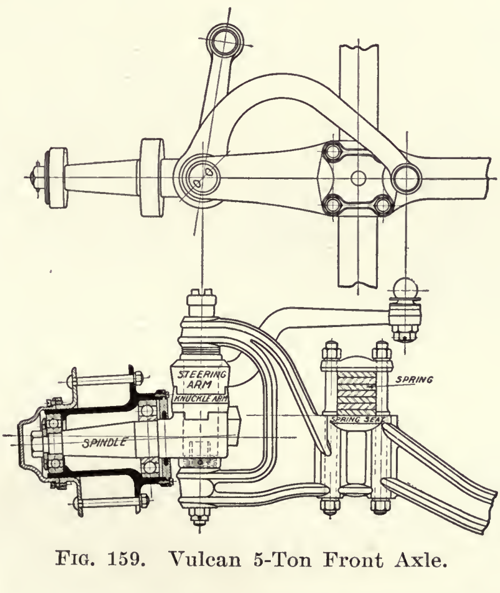

FIG. 159. Vulcan 5-Ton Front Axle.

attached to the frame and the action of the springs tend to vary the distance between the frame and the axle. The hubs are malleable castings with flanges, which hold the spokes of the wheel.

Cup and cone ball bearings are used for mounting the hubs on the spindle. Bearing adjustment is by means of a nut on the spindle and spacing washers.

The Vulcan Front Axle.—The Vulcan five-ton axle (shown in Fig. 159) offers an example of heavy vehicle construction arranged for fore and aft steering, with the tie rod located to the rear of the axle.

The axle center is a drop forging with integral spring seats. These spring seats are placed as close as possible to the wheel center in order to obtain the maximum capacity. The stress, due to both the combined weight of the vehicle and its load and that due to the wheel striking an obstruction, increases from nothing at the center of the wheel to a maximum at the center of the spring seat. For this reason a minimum distance is desired. It is customary to increase the section of the axle center between the knuckles and spring seat centers, both in a vertical and horizontal plane to withstand this stress. The knuckles on this axle are also of the Elliot type, but instead of forging the spindle integral with the knuckle pivot and keying the arms to the former, these parts are forged separately and keyed together by integral keys. The pivot pin has a shoulder at one end and a nut at the other end to hold them together and the entire unit is supported by bushings and thrust washers in the fork of the axle center. The hub construction is of conventional design, employing annular ball bearings for wheel mounting.

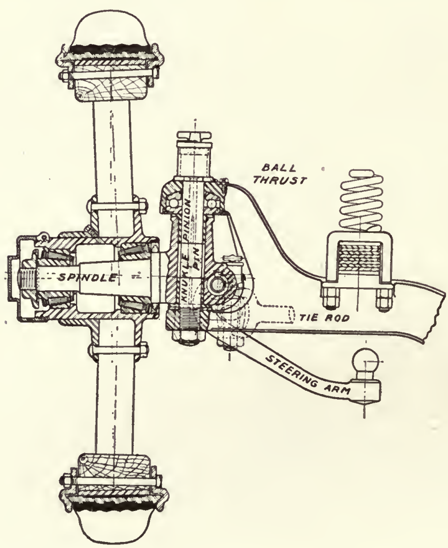

Fig. 160. Peerless Front Axle.

The Peerless Axle.—Fig. 160 depicts the Peerless front axle, which is built along conventional lines with drop forged center, integral spring seats and Elliot type knuckles. In detail, this construction differs from those mentioned above in that the bushings for supporting the pivot pin are located in the knuckle instead of in the axle fork. Thrust washers are replaced by a ball-thrust bearing, located in the upper part of the fork. The steering arm is forged integral with the knuckle arm and attached to the knuckle by a taper and key. The steering arm being so arranged as to clear the lower surface of the center. The front wheels are mounted upon Timken roller bearings and dished, that is, the wheel spokes are set at angles with a plane perpendicular to the axis of the wheel.

The Timken Front Axle (Fig. 161) is used on a number of commercial cars. It has a drop forged center of I-beam section, and Elliot knuckles. The axles are arranged for either type of steering to meet the requirements of vehicle makers. However, in this case the cross steering arrangement with the tie rod and drag link located in front of the axle is shown. The knuckle and pivot pin are locked together with a bolt, so that this part is properly supported by the Timken bearing in the axle fork. Timken bearings are also used for wheel mounting.

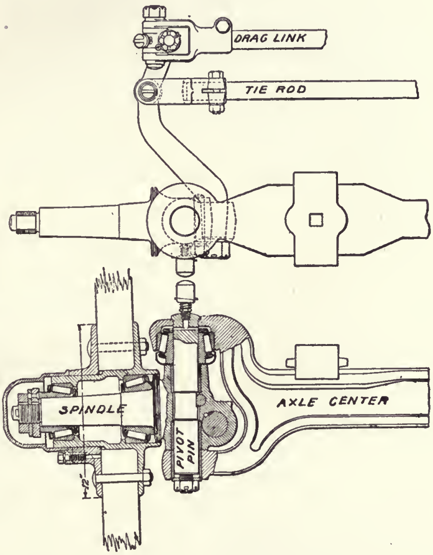

Fig. 161. Plan and Side View of Timken Front Axle.

The axles mentioned above are all arranged for right-side steering, while the Natco axle (Fig. 162) arranged for left-side fore and aft steering with the tie rod located at the rear of the axle. It is of conventional design with Elliot knuckles and pivot pin bushings located in the knuckles. This illustration shows how the center is dropped to provide the proper clearance between it and the radiator or other units which may be near it. It also shows the method of providing clearance for the tie rod and it will be noted that this is not bent to the shape of the axle, as provision must be made to compensate for the movement of the knuckle arms. This axle is an example of light truck construction, and also presents one method of driving the speedometer by gearing from the wheel.

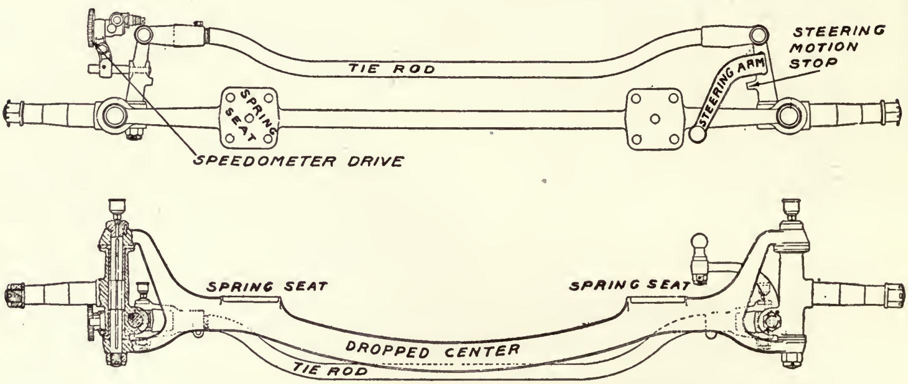

FIG. 162. Natco Axle Top and Side Views.

Pierce Axle.—The Pierce worm-driven trucks are equipped with front axles having reversed Elliot type knuckles and fore and aft right-hand steering. The axle center is an I-beam section

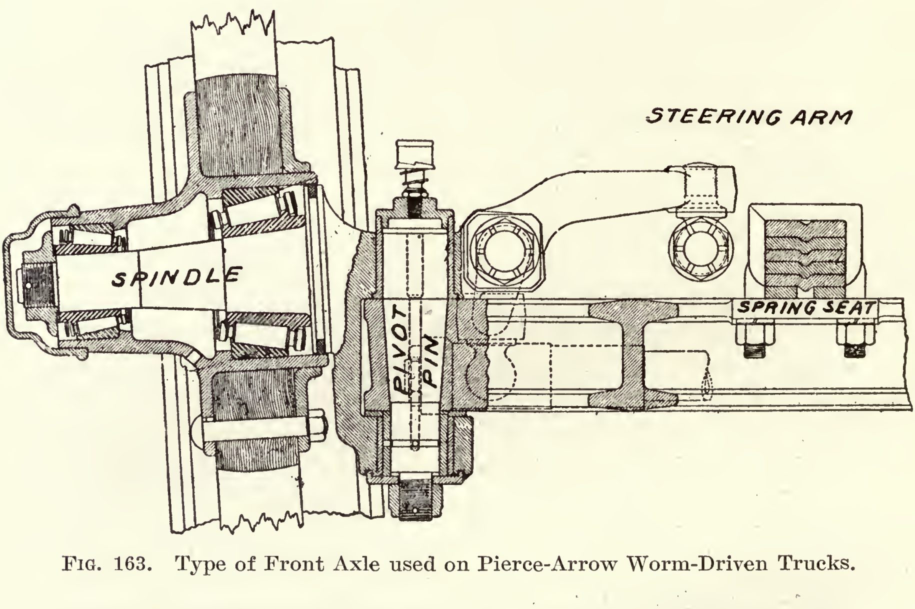

FIG. 163. Type of Front Axle used on Pierce-Arrow Worm-Driven Trucks.

forging and is perfectly straight, with integral spring seats. The pivot pin bushings are located in the knuckles and so arranged that the thrust is taken by the shoulders of these bushings and a thrust washer. The pivot pin has a taper which fits into the axle center so that it can be drawn up tight by a castellated nut. The wheels are mounted on Timken roller bearings as shown in Fig. 163.

Packard Axles.—The new Packard worm-driven trucks are equipped with front axles (Fig. 164), employing the reversed Elliot type of knuckle; however, they are arranged for left side fore and aft steering. The axle proper, however, is dropped at the center. This construction is similar to the one depicted above, with the exception of the steering arms, which are attached to the lower part of the knuckle. This permits proper clearance for the tie rod and places it in such position that it is not necessary to bend it. A feature worthy of attention on both of these axles is the provision of ball and socket connections for the tie rod and drag link in place of the more customary clevis and bolt. These ball and socket joints have springs so that the wear in the steering connections is automatically taken up.

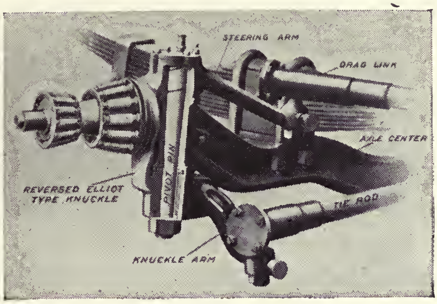

Fig. 164. Packard Front Axle.

The International Harvester Corporation trucks for some years had used the Sarven type of wheel in connection with an Elliot type of steering knuckle, in which the pivot center lies very close to the center of the wheel. This is shown in Fig. 165 and it will be noted that the hub construction resembles an ordinary vehicle wheel hub. This consists of wooden hubs with steel hub flanges, the former have steel shells which carry the wheel bearings. The outer wheel bearing is of the roller type

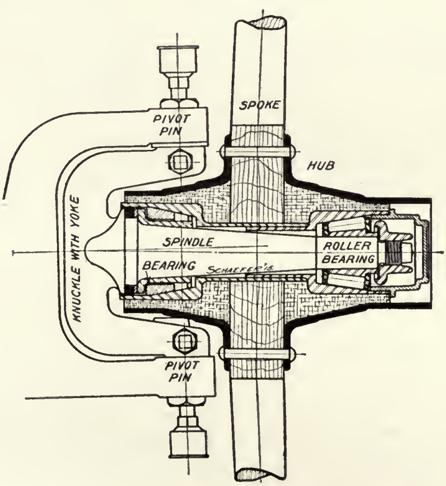

Fig. 165. Axle used on some of the International Harvester Trucks.

made by the I.H.C., while the inner bearing consists of a steel and bronze shell, the latter having a taper bearing in the shell inserted in the wood hub. The bronze shell is provided with oil holes and grooves, so that the entire bearing can work in graphite and grease. The knuckle, instead of having the usual hub for the pivot pin or king bolt, as it is sometimes called, has a yoke, which fits into the axle yoke. Short pins pass through the axle and knuckle yokes to form the pivot.

The above axles all have drop forged centers, which may either be forged in one piece or the two ends may be forged separately and welded together at the center.

The Reo Axle.—The Reo two-ton front axle (Fig. 166) differs from those shown above in that the center is built up from a bar of round section, pinned and brazed into cast steel ends which form the forks. The knuckles are of the Elliot type and carry the bushings for the pivot pin. The knuckle arms fit over the

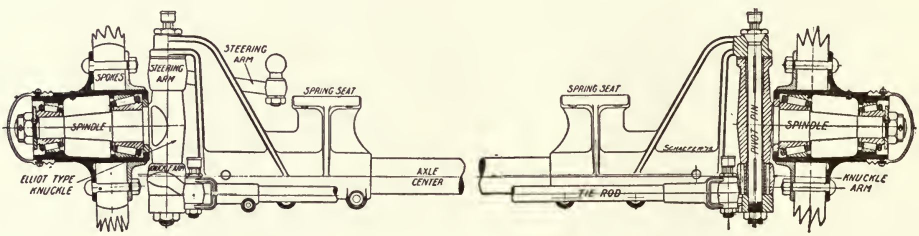

FIG. 166. Reo 2-Ton Front Axle.

ends of the knuckle and are held in unison with knuckle by two keys. This axle is arranged for left-side steering and the tie is placed directly back of the axle bed. It is not necessary to bend it, since ample clearance is obtained by placing the spring seats above the wheel center. The wheels are mounted on Timken roller bearings and retained by a castellated nut and keyed washer.

Vim and Commerce Axles.—The Vim and Commerce trucks also employ built-up axles with Elliot knuckles, but the center or bed is made of tubular section. The Avery farm trucks employ another type of built-up front axles. A malleable casting forms the steering head to receive the Lemoine type of knuckle, which is equipped with a series of hardened steel washers to take the thrust.

On either side of the steering head extensions are riveted a couple of steel plates as shown in Fig. 167. These are straight at the spring seats and bent up slightly at the ends to attach to the steering head castings. Blocks are placed between the two axle plates directly under each spring to form the seat. The steering connections are arranged for cross steering and are located in front of the axle.

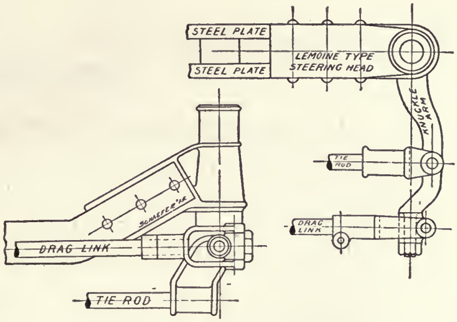

Fig. 167. Lemoine Type of Knuckle.

The three-wheel "Wayne Light" commercial car having a capacity of 800 lbs. also employs a built-up front axle as shown in Fig. 168. Two sections of rolled channel steel are riveted together and with drop forged yokes and Elliot type knuckles at either end.

Pressed steel centers may also be used, while combinations of the above types may also be worked out.

Bearings.—All American trucks are equipped with anti-friction bearings such as the ball and roller types, which are capable of carrying both a radial and thrust load. The mounting of these bearings presents no difficulty and they are usually provided with adjustments to compensate for wear. The tie rods and drag links are made of tubular section and are provided with adjustments so that the alignment of the wheels may be properly maintained. Lately there seems to be a tendency to use the ball and socket joint for these in preference to the clevis. The former will to a considerable extent take up the wear automatically and can also be more efficiently lubricated.

Fig. 168. Wayne Light Axle, Built-Up Type.

CHAPTER XIV

STEERING GEARS AND FUNDAMENTAL PRINCIPLES OF STEERING MECHANISMS

Certain Principles That Must be Understood in Designing Them.—Some interesting problems pertaining to the design, construction and operation of the modern commercial car are found in the various steering mechanisms employed. Like almost every other important mechanical features, the steering devices now in general use have resulted from a careful study of the conditions to be fulfilled, supplemented by extensive experiments with different types. These researches have resulted in a general steering system which is applied in different forms to all standard commercial vehicles. This, in brief, consists of a hand-wheel, connected through some form of linkage and gearing leverage to the front wheels of the vehicle, these wheels being carried on pivoted ends of the front axle. The design and construction of some of the most important features of this general arrangement afford interesting subjects for discussion.

Throw of Front Wheels.—Commercial vehicles must necessarily be operated within a limited space such as a narrow street, and it is of importance that the extreme throw, from side to side of the front wheels be settled upon, as the amount of this throw, together with the wheelbase and tread determines the turning radius. In practice the latter two items are established by the load or body requirements, and with these fixed, the throw of the front wheels is usually limited by the width of the body, frame or springs and the permissible distance between the pivot centers about which the wheels swing. The angles which the connecting linkage make, become too acute or obtuse according to their location, if the maximum throw of the wheels is made more than 35 degrees. If this throw is exceeded, steerage is difficult and unsafe.

The theoretical center about which the vehicle turns is somewhat in the center line of the rear axle prolonged, the exact location being determined by the intersection of this line by a line drawn normal to the inside front wheel. Another line drawn from this intersection to the center of the outside front wheel should be normal to this wheel if it is at the correct angle to prevent excessive side slip, which is very destructive to the vehicle

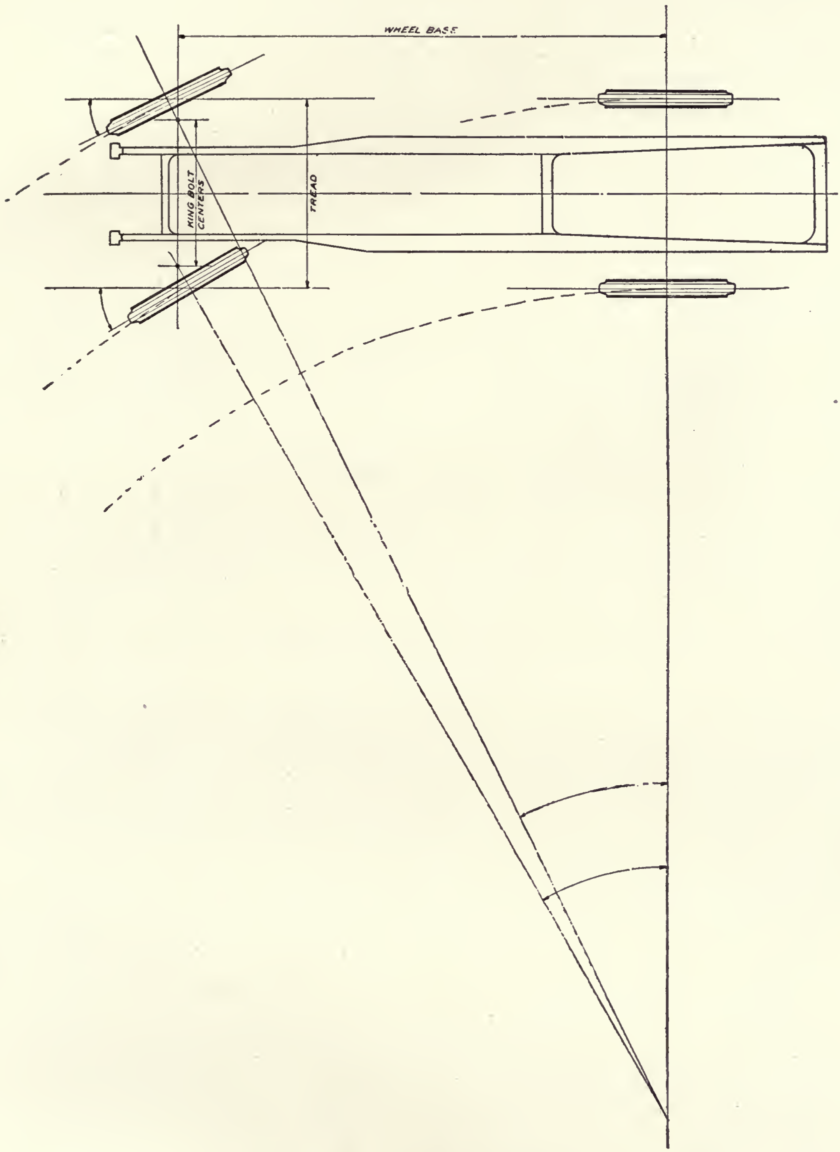

Fig. 169. Relation of Front and Rear Wheel in Turning.

tire. The four wheels will describe concentric circles about this theoretical center. This is clearly illustrated in Fig. 169 and it will be noticed that the minimum turning radius is the radius of the arc described by the outer front wheel when these wheels are in the position of maximum throw. The differential device allows the proper relation of speed between the rear wheels.

The outer front wheel pivot is turned a smaller angle than the inner, and they are connected, by a cross rod, rigidly attached to them. There must be some compensating device interposed to give the same angular relation when the wheels are turned in the opposite direction. This is accomplished by making use of the principle of varying ratios of sines of the angles at different

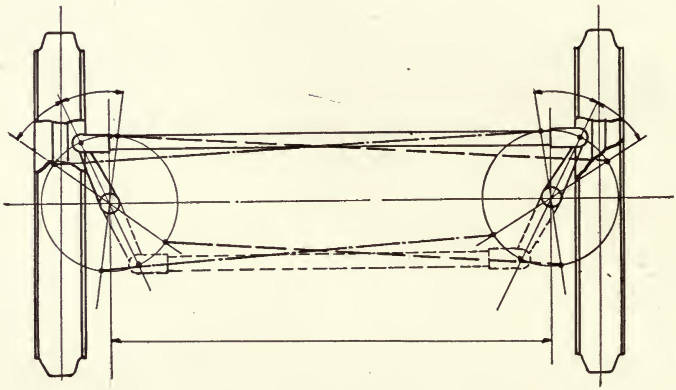

Fig. 170. Arrangement of Knuckle Levers and Tie Rod for Front and Rear Positions.

points in the arcs through which the knuckle levers turn. This necessitates locating the pivot or knuckle levers so that their centers diverge if they project ahead of the axle, and converge if they project back of it. As the wheels swing, the knuckle lever mounted on the spindle of the inner wheel travels away from the dead center arc, thus traveling a smaller angular distance. This is illustrated by heavy lines, Fig. 170, which are shown for both front and rear location of the cross-rod.

Knuckle Lever Angles.—There are various methods of theoretically determining the proper angles of these levers, either mathematically or graphically; however, this is largely a matter of compromise, between what is theoretically correct and what is attainable practically. Some makers follow the practice of laying out these steering connections so that the center line of the knuckle lever extended will intersect the center of the rear axle. Others endeavor to obtain a knuckle lever length and angle, that while fitting into the general layout of the vehicle, gives the largest possible range of steering angle without undue error. This is generally determined more by experience than by any figures. Another point which must be considered in the general layout, is the various lengths of wheel bases and this suggests making the angle of the knuckle levers as small as possible, consistent with reasonable clearance between the ends of the cross tube and the spokes of the wheels.

Location of Knuckle Levers.—Both front and rear positions of these two levers are used and each position possesses its advantages and disadvantages. Some makers prefer the forward location for the reason that it enables large steering angles to be used safely, thus diminishing the turning radius of the vehicle. With the rear position the tie-rod, connecting these two levers, is better protected from injury, providing the proper clearance can be obtained under the engine base. The length of this tie-rod is so adjusted that with the front wheels in the central position the distance apart of the wheel felloes at the height of the spindle is from 3/16 in. to 5/8 in. less in front of the axle than back of it. The amount of toe-in depends upon the diameter of the wheel, the lower figures being used for wheels 34 ins. or less. This toeing-in is intended to allow for slight play in the joints of the tie-rod and the flexure of its members. It is also intended to correct the tendency of the wheels to toe outward when the vehicle is moving.

Inclination of the Wheel Spindles.—The spindle upon which the wheel revolves is generally inclined from $1\frac{1}{2}$ to 2 degrees below the horizontal center, while the king bolt about which the wheel pivots is brought as close to the spokes as possible, in order to bring the point of intersection of the center of the wheel with the ground as close to the center of the bolt produced as possible. This distance forms the lever arm at the end of which the resistance to motion of the front wheels acts when the wheels swing around for steering.

To approximate castor steering, some manufacturers also incline the axles and king bolt in a fore and aft plane, as in Fig. 171, the inclination being about four degrees on the average. The reasons for these features are that they make steering easier, in that the construction produces a trailer effect which tends to obviate serious consequences in the event of breakage or disconnection of the steering linkage. The point of wheel contact with the ground is behind the point at which the center of the king bolt produced meets the ground, hence the steering wheels trail and are automatically kept in the straight ahead position by the road resistance. This trailer effect somewhat reduces wobbling of the front wheels and also reduces the shock on the steering gear.

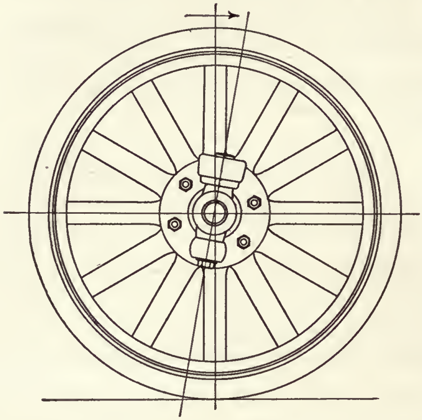

Fig. 171. Trailer Effect when Castor Steering is Approximated by Including King Bolt.

Reversibility of Steering Gears.—To prevent road shocks from being transmitted to the operator's arms, it is considered best to have the steering gear backlocking, or irreversible to some extent at least. With a perfectly reversible system it is evident road shocks, which are transmitted to the operator's hands, depend on their magnitude and the lever arm through which they act. This system is best adapted to show moving vehicles running over smooth pavements, such as the light electric vehicles in common use.

Between the limits of reversible and irreversible steering gears, is the semi-reversible type, which allows the vehicle wheels to be turned independently of any effort exerted on the steering wheel, yet exerting an even resistance to movement. This feature allows the road wheels to follow the path of least resistance and at the same time indicates to the operator the extent and direction of the movement by more or less swerving of the steering wheel depending upon the gear ratio. The semi-reversible system also relieves the parts of considerable strain which would be present if the vehicle wheels were rigidly held to their position. A disadvantage of the semi-reversible feature is in steering through sandy or muddy roads and in crossing obstructions such as car tracks obliquely.

Irreversible Gear for Heavy Service.—Heavy service seems to offer a logical field for the irreversible gear as the connection may be made heavy and strong. Considerable manipulation of the steering wheel is usually necessary on these vehicles, which tends to make this type a favorite by relieving the operator of jerks and considerable muscular exertion on the steering wheel. It also permits a very low gear ratio or large hand wheel motion which is quite desirable from the leverage standpoint in operating a heavy vehicle when at a standstill or moving very slowly.

Steering-gear Ratios.—Because a commercial vehicle is heavier and slower than a pleasure car, it necessarily has a different kind of steering gear. Theoretically the layout would be the same for both machines, if they had the same wheelbase, but practically it is necessary to have a greater reduction in the commercial vehicle because it is heavier and naturally takes a greater leverage to turn the wheels; and also, since this vehicle acts at a slower rate of speed, the reduction can again be greater because it is not so necessary to be able to turn the wheels from one side to another quickly.

Owing to the great inertia of a moving loaded commercial vehicle, it is not desirable to make quick turns with the front wheels on account of the tremendous stresses involved by the inertia force and the high center of gravity.

The term, irreversible, in itself, is confusing because it has no exact meaning when applied to a steering gear, beyond the rather indefinite condition, that it means that any ordinary road wheel impact will be insufficient to turn the steering wheel. It is simply a question of reduction between the worm and gear or screw and nut, whichever system is used. The greater the reduction the less reversible the system and likewise the slower the motion of the road wheels in relation to the movement of the steering wheel. Hence, the steering mechanism for a heavy vehicle will be less reversible than the steering mechanism for a lighter vehicle.

Tie Rod.—The tie rod connects the steering knuckle levers on opposite sides and is usually of tubular section. When placed in front of the axle it ordinarily works under tension, while behind the axle it works under compression. In the forward position the road resistance encountered by the front wheels, acting through the steering knuckles and arms, puts a tension on the rod and in the rear position a compression. The force impressed by the operator in steering the vehicle produces a tension for one direction of motion and a compression for the other, with both constructions.

The ends of the knuckle levers swing in the same plane and the tie rod must be connected with forked connectors. These connectors are generally made adjustable, so that the wheels may be kept properly lined up even if the rod or steering levers become slightly bent. The adjustable connectors must be securely clamped and safeguarded against working loose.

The Drag Link.—The drag link may be placed either in a fore-and-aft position or crosswise of the vehicle. The fore-and-aft position is more generally used when the engine is under a hood, while with the seat over the engine it is difficult to place the gear in such a position as to permit placing the drag link parallel with the frame. The gear usually is so close to the front axle that the drag link must be placed crosswise.

Cushion springs are usually put in the joints of this member to assist in absorbing abrupt shocks which might be transmitted in either direction. These members sometimes are made adjustable for length, while adjustments are also provided to take up the tension on the springs.

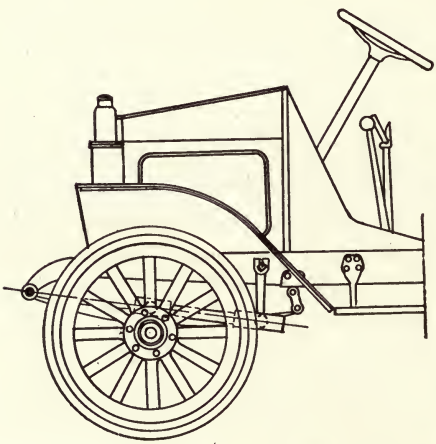

Fig. 172. Steering Gear Back of Axle and Drag Link Parallel with Frame.

An important point in the steering gear layout is a desirability of a proper geometrical layout for the drag link to avoid front wheel wobble under front spring deflection when the vehicle is in motion. In other words, it is very important to have the drag link so arranged as to produce the least tendency to rotate the steering gear arm as a result of the action of the front springs. When this member is placed crosswise it should be in nearly the same plane as the tie rod under normal load, but with the fore-and-aft position conditions are entirely different. With this arrangement the drag link may be either forward of or behind the front axle. In the latter position, which is the more popular, this link should be so placed that when the truck is loaded, a straight line drawn through the eye of the front spring will approximately intersect both front and rear ball-joint centers of the drag link, as in Fig. 172. A slight deviation from this intersection will not materially affect the results, depending upon the characteristics of the front spring, but the centers must fall approximately on this line to obtain the proper front wheel action under spring deflections, particularly when such spring deflection is at all excessive. To give as nearly as possible true steering under extreme conditions, it is well to make the front spring as flat as possible, to prevent any great extent of forward or backward movement of the axle.

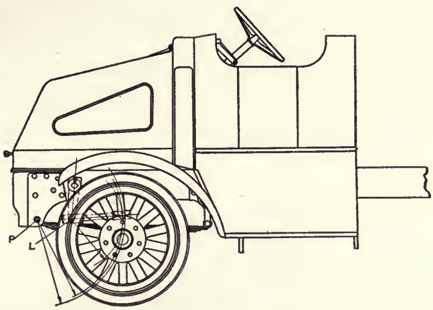

Fig. 173. Mack Model "AC" Steering Gear Arrangement.

On the Mack model "A.C." trucks (Fig. 173) the steering gear and drag link are ahead of the front axle. This member is slightly out of parallel with the frame, when the mechanism is in midposition, but swings into position more nearly parallel when the road wheels are turned. The front axle, in its movements, due to road inequalities, swings through an approximate arc about a point *P*. The ball on the steering knuckle-arm is as close to this point as conditions permit. The drag link, extending backward, swings about a center *L*. Thus, both the axle itself and the ball on the steering knuckle-arm swing through approximately concentric arcs and no backward or forward motion is imparted to the steering gear arm due to spring deflection.

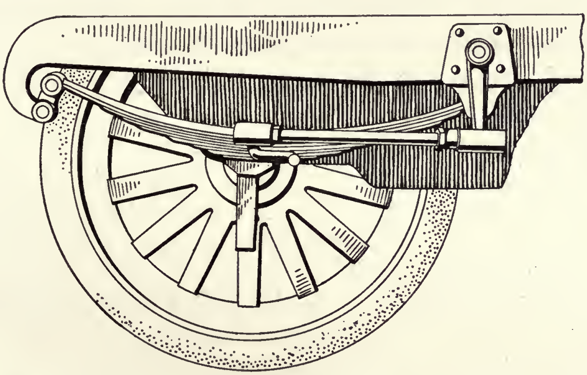

Fig. 174. Manly Front Spring Mounting.

On the Manly trucks a similar arrangement is used; however, this is just the reverse to that of the Mack trucks, in that, the front end of the spring is shackled and the rear end rigidly attached to the frame. By this method the end of the drag link, which is pivoted on the steering gear arm, is brought very nearly in line with the pivoted end of the spring so that the axle and the forward end of the drag link connected with the axle is allowed to travel in practically the same curved path.

The Steering Gear.—Horse-drawn vehicles are ordinarily steered by means of a fifth-wheel attached to the forward unit of the vehicle gear, which pivots on what is known as the king bolt. However, the divided axle is universally employed on commercial cars. This was described in the preceding chapter on "Front Axles," and the arrangement of pivoting the wheels is known in the country as the Ackerman Steering Gear.

Technically, this has been revised and at present it is based upon the principle that if the vehicle is to turn a corner without lateral slip of any of the wheels, the steering linkage must be so arranged that the axles of all wheels produced always intersect a common vertical line, this vertical line forming a momentary axis of rotation. This accounts for the use of inclined knuckle arms instead of parallel arms. When they extend toward the rear they must incline toward each other and away from each other when they extend forward of the axle. The inclination is such that the center lines of the arms produced meet at the point near the center of the rear axle.

Wheel and Mast.—Commercial cars are steered by means of hand wheels located at the upper end of the steering column. The spider of the steering wheels is secured to a shaft which generally passes down through an outer tube, usually called the mast. This shaft enters a housing at the lower end, which carries the steering mechanism that may either consist of a rack and pinion bevel pinion and bevel sector, worm and sector, worm and wheel, or screw and nut.

The steering column is generally styled according to the type of steering mechanism employed. One member of the mechanism has a shaft extending through the housing and carries the steering lever which is connected by means of a drag link to the steering arm on the front axle. Generally the steering motion is geared down so that one and one-half turns of the hand wheel will give the steering ball arm a motion of about 60 degrees, while the lever proportions are such as to give the wheels the maximum angle in either direction.

For commercial cars, especially those designed for heavy service, it is considered best to have the steering gear back-

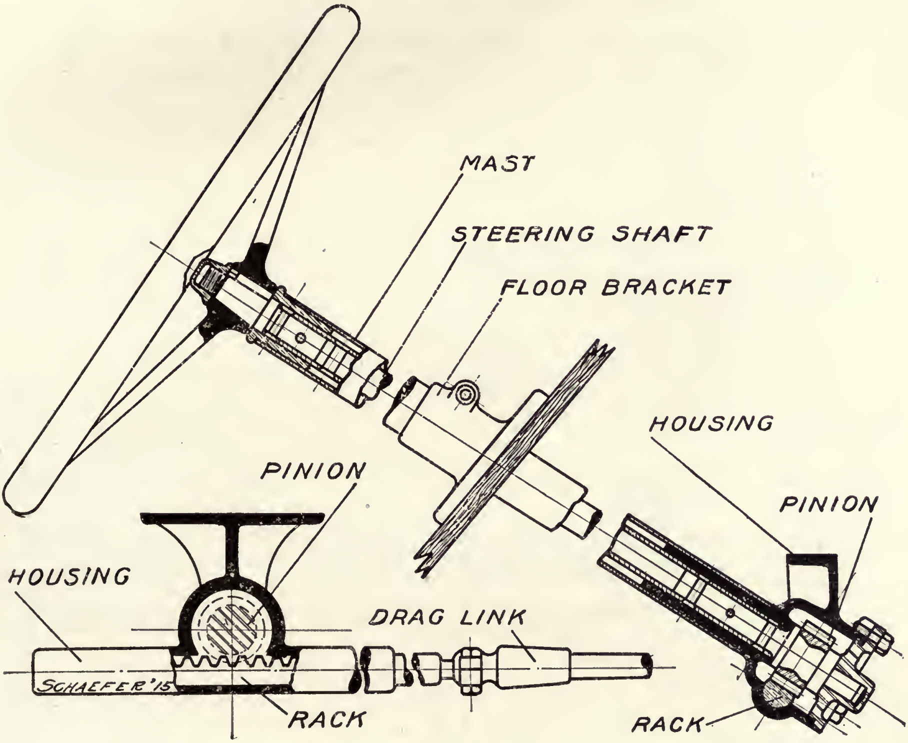

FIG. 175. Rack and Pinion Type of Steering Gear.

locking or irreversible, that is, so designed that any shocks received by the road wheels will not be transmitted to the operator's arms. The lighter vehicles permit the use of a slightly reversible mechanism, in which part of the shock is transmitted to the operator's arms, thus reducing the shocks transmitted to the steering mechanism.

Drag Links and Tie Rods.—Drag links are usually of the same proportions as the tie rod of the axle and the general practice is to provide cushion springs to absorb some of the shock which is transmitted to the steering mechanism. There are various constructions of either the steering mechanism or drag link in use at of completeness, it will be necessary to present some illustrations, if clearness is to be a property of the text.

Rack and Pinion Type.—The rack and pinion type of steering gear (Fig. 175) is perhaps the simplest type. It consists of a hollow steering shaft which carries the hand wheel at its upper end and a spur pinion within a housing at its lower end. This pinion meshes with a spur rack the end of which extends through

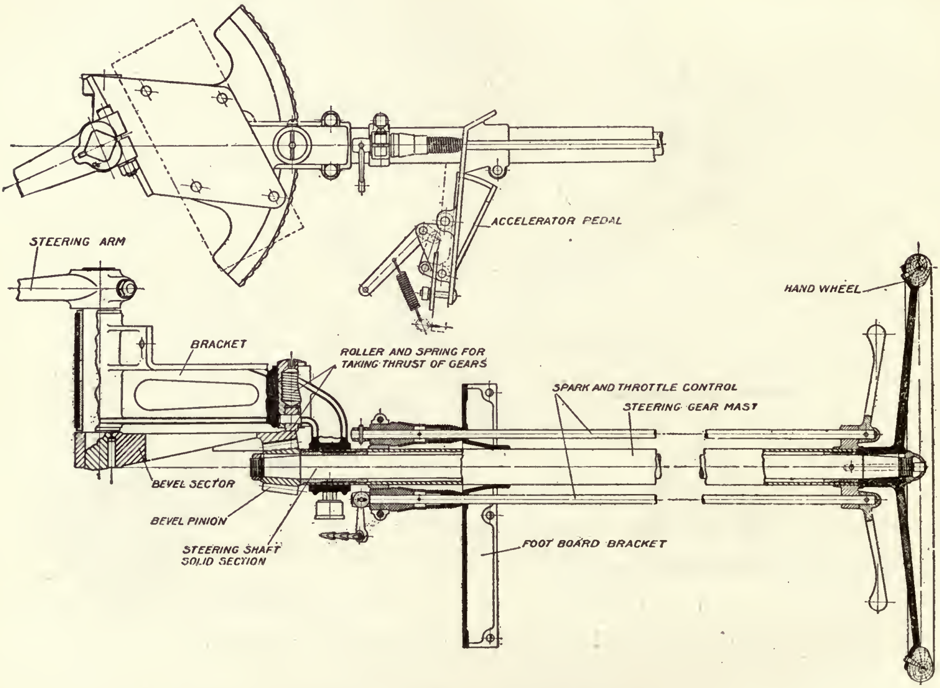

Fig. 176. Reo Bevel-Type Gear.

the housing and carries a ball to which the drag link is attached. The column has an outer tube or mast which carries a bearing for the steering shaft.

This type of steering mechanism is only used for cross steering and is completely reversible, so that the road shocks are transmitted to the operator's arms. It is practically limited to use on cars of 1,000-lb. capacity and under, and where the steering pivots can be so arranged that only part of the motion of the road wheel can be transmitted to the steering mechanism. It also possesses a disadvantage in that all the load is carried on one tooth, as the space in the chassis frame is not large enough to permit the proportions needed to have two or more teeth in mesh.

Bevel-pinion Type (Fig. 176) illustrates the bevel-pinion and sector type of steering used on the Reo 2-ton chassis. In this construction the steering shaft is made of solid section, which permits securely keying the hand wheel and bevel pinion to it. This, of course, is made possible by placing the spark and throttle control outside of the steering column and locating the levers below the hand wheel.

The bevel pinion meshes with a bevel gear sector which is attached to a horizontal shaft carrying the steering ball lever. The steering motion is limited by leaving a portion of the sector without teeth, while the thrust of the sector is taken on a steel roller, a spring being used to maintain the roller in contact with the sector. A large bracket forms the frame attachment and also

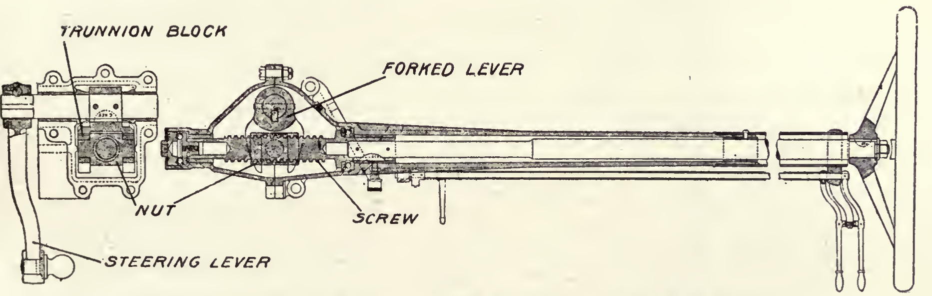

Fig. 177. Steering Gear of the Pierce-Arrow 5-Ton Truck.

carries the bearings for the horizontal shaft, the thrust roller and supports the lower end of the mast.

The spark and throttle controls, instead of having the usual sector near the hand wheel, are controlled by means of friction members and springs, located below the foot board bracket, while the accelerator pedal is also mounted on this bracket.

Bevel gear steering mechanisms have less need for housings than other types, although in some cases they are enclosed. This type of gear is also completely reversible.

Worm and Sector Type (Fig. 180) depicts the worm and sector type of steering used on the Vulcan 5-ton chassis. It has ball-thrust bearings and a hollow shaft, however, but one control, that of the throttle is built in the column, the spark being controlled by mechanism mounted on the dash. The lower end of the steering shaft having an integral worm. This worm meshes with a worm-gear sector mounted on a horizontal shaft and supported by bushings located in the horizontal divided case.

The customary position for the steering ball lever in the worm type of steering gears, is on the horizontal shaft; however, this position generally limits the motion of the front wheels on the side on which the steering gear is located, as the road wheel will come in contact with the drag link before it can touch any other part. With fore and aft steering the usual method of overcoming this is by placing the steering arm of the axle below the axle center and mounting the steering gear in such a manner as to permit the drag link to clear inside the front spring. However, this places the steering linkage in a position where it is practically the lowest point of the vehicle and very apt to become damaged by striking obstacles in the road. In heavy vehicles considerable clearance is usually allowed between the front spring and the frame, and in the Vulcan 5-ton truck this clearance is taken advantage of to protect the steering linkage, by passing the steering arm of the axle through this space so that the drag link comes inside the frame. However, owing to the limited amount of space between the engine and the frame, the steering ball lever cannot be mounted on the horizontal shaft outside of the housing. In order to overcome this, the worm sector of the steering gear has a boss which extends through case and carries the lever. In this way the lever is placed in approximately the center of the column and has ample space for its full movement.

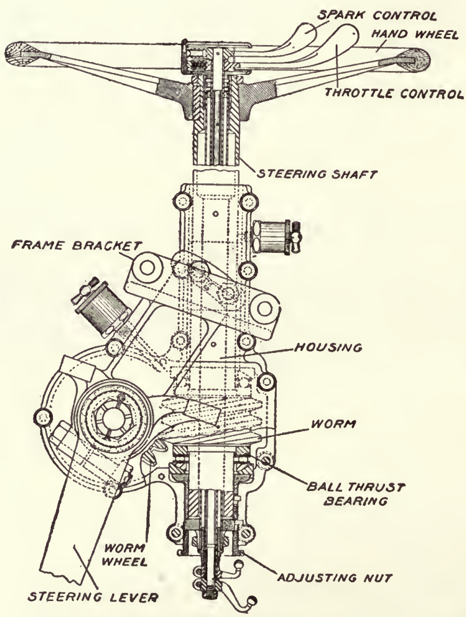

FIG. 178. Peerless Steering Gear. Worm and Wheel Type.

Worm and Wheel Type.—The Peerless steering gear (Fig. 178) differs somewhat from those shown above, being of the worm and wheel type with friction controls mounted above the hand wheel. This hand wheel is attached to the steering shaft by means of a taper and key, while the former is made large enough to form both the shaft and the mast.

With inside controls and a mast, there is considerable difficulty in providing a shaft of proper proportions, so that in eliminating the mast, the shaft can be made ample in size. Although it is somewhat more difficult to provide a bracket on the foot boards, owing to the shaft turning with the hand wheel.

In this construction a complete worm wheel is used instead of a sector, and as only about 90 degrees of the worm wheel comes in contact with the worm teeth, while the wheels are moved their entire turning range, and as the shaft is squared, the steering arm can be removed and the wear taken up by turning the wheel through an angle of 90 degrees, and another quarter section brought into action. The thrust is taken on ball bearings in either direction. The controls consist of a stationary tube on top of which is mounted a cylindrical box, with a horizontal slot in one side through which the control levers extend. Each control lever has an extension, which carries a friction segment, being pressed against the inner wall of the cylindrical housing by a spring. The lower end of this stationary tube is rigidly attached to the housing so that it cannot rotate.

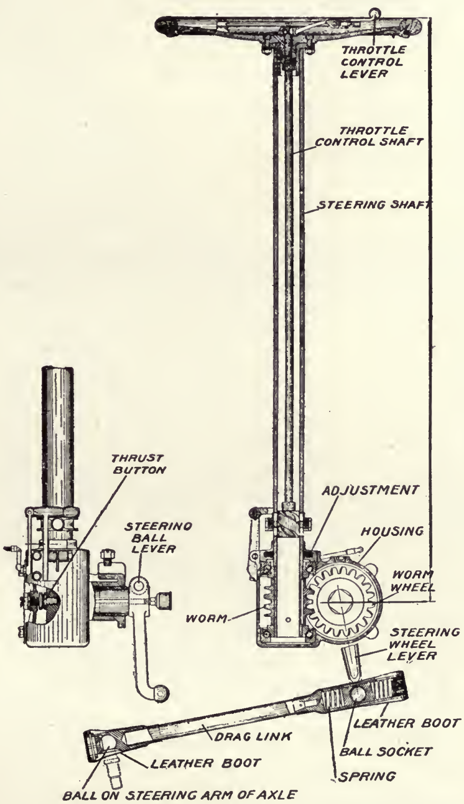

Fig. 179. Natco Steering Column.

A shaft and tube pass through the former to which the upper and lower levers are attached.

The Natco steering gear (Fig. 179) is also of the worm and wheel type with suitable ball bearings to take the thrust of the worm, while a thrust button takes care of the wheel thrust. The housing is made in one piece with openings for introducing the worm and wheel. In this construction the steering shaft is also used as the mast; however, the wheel is attached to the shaft by bolts and flanges. But one control is provided, with the lever located above the hand wheel; however, instead of passing the control shaft through the case, the movement of the control lever is transmitted externally by means of a double thread screw or cam. The steering shaft has slots on opposite sides directly above

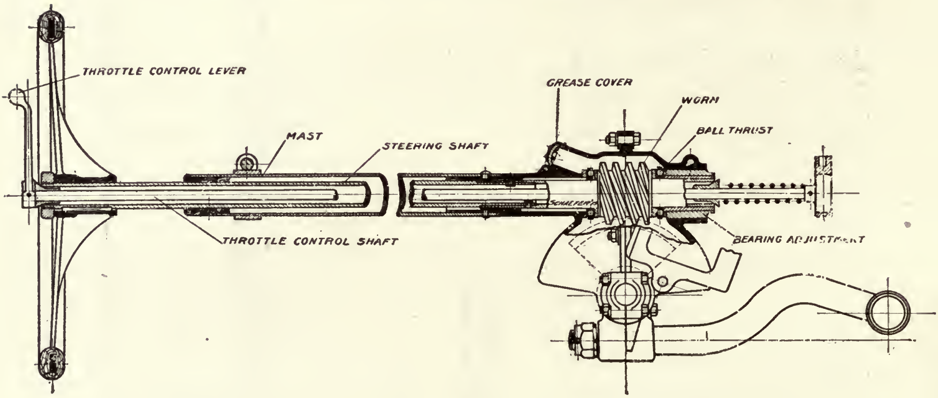

FIG. 180. Vulcan Steering Gear. Worm and Sector Type.

the housing. These are enclosed by a collar which fits over the steering shaft and carries two dowel pointed screws, which set in threads of the cam. A fork rests on this collar and any movement of the control lever will tend to raise or lower this collar, carrying with it the fork which is connected to the carburetor.

Screw and Nut Type (Fig. 177) illustrates a screw and nut type of steering used on the Pierce 5-ton chassis. The solid steering shaft has the hand wheel keyed to its upper end and a multiple square threaded screw at its lower end. This screw actuates a nut with trunnions on its outside which carry die cast trunnion blocks that slide within the jaws of a forked lever, keyed to the steering ball lever shaft. The housing is divided horizontally and carries suitable ball thrust bearings, which are adjustable from the lower end of the housing. The spark and throttle controls are of the ratchet and sector type mounted outside of the column on the steering column mast.

Another screw and nut type of steering gear which is used on a number of trucks is the Ross. shown in Fig. 181. The hollow

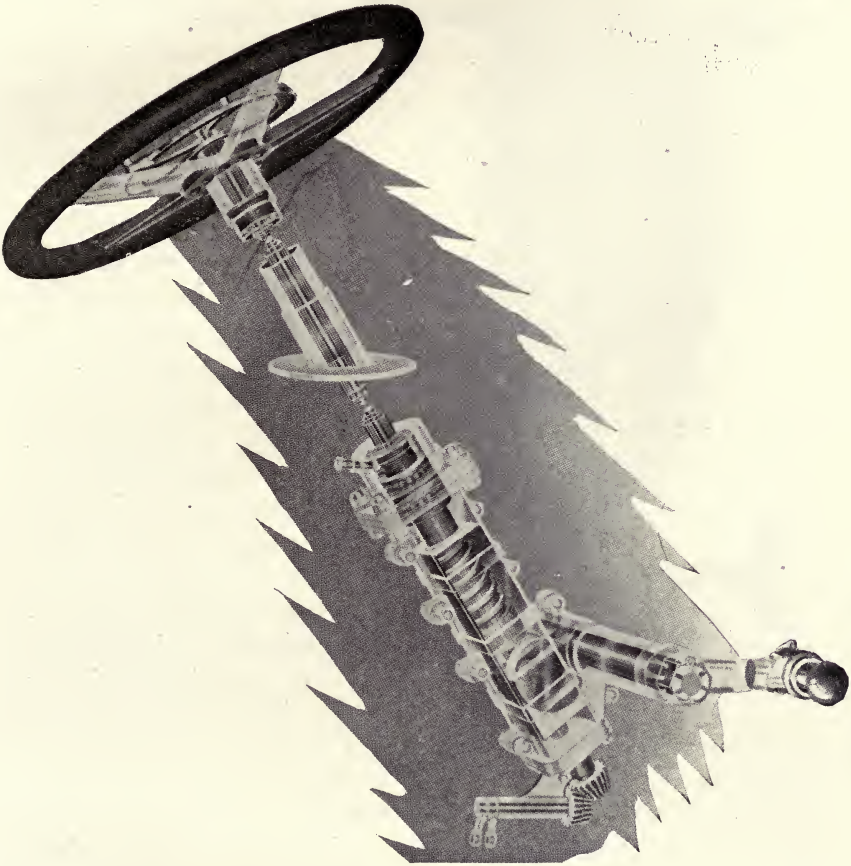

Fig. 181. Ross Screw and Nut Type Steering Gear for Fore and Aft Steering.

steering shaft carries a steel screw at its lower end mounted between two ball bearings to take up its end thrust. This screw is held to the shaft by means of a brazed joint and when the hand wheel is turned a steel block or sleeve is given later movement. This steel block or sleeve has a square external section and thereby is prevented from turning by the housing. On each side of the lower end of this sleeve, cylindrical recesses are turned, and cylinders, which are free to rotate, are placed in these recesses. The cylinders have slots milled in them which receive the projecting arms of the steering ball lever shaft.

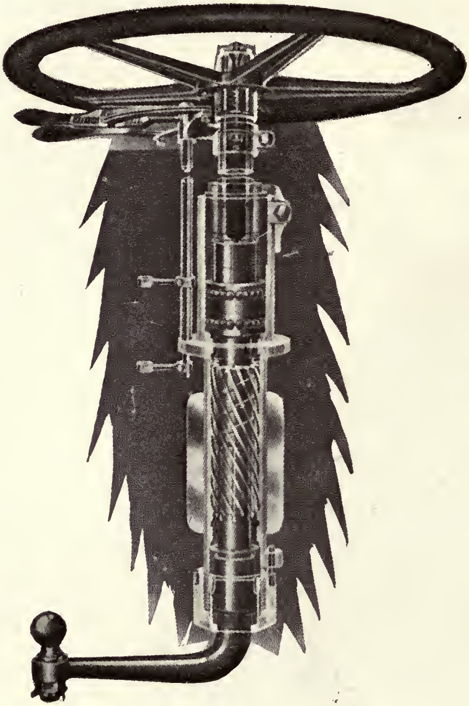

FIG. 182. Ross Screw and Nut Type Steering Gear for Cross Steering.

The control levers are mounted above the wheel and their shafts pass through the steering shaft. The motion of these levers is reduced at the lower end by means of bevel gears.

Cross Steering.—All of the gears depicted above are best adapted to fore and aft steering, although they may in some cases be arranged for cross steering. Fig. 182 illustrates the Ross screw type of gear, especially designed for cross steering on heavy vehicles. The lower end of the steering shaft is integral with a steel screw, which, when turned by the hand wheel, gives a bronze sleeve longitudinal motion. This bronze sleeve is threaded internally to receive the steel screw and has spirals milled upon its external surface. The housing has spirals cut on its internal surface which engage with the spirals on the sleeve. The bronze sleeve in addition to internal threads contains a number of straight key-ways. The steering ball lever which projects half way up into the sleeve has integral keys, so that when the sleeve is given rotative and longitudinal motion, it rotates the ball lever. The gear is provided with ball-thrust bearings and an adjustment to take up wear, and can be made semi-irreversible or irreversible, depending upon the ratio of the threads.

Drag Links.—In Fig. 179 is shown a type of drag link used on vehicles up to about two tons capacity. It has ball sockets which fit over the ball on the steering arm of the axle. One of the ball sockets is brazed or welded to the drag-link tube and has an opening to receive another socket, which is retained by a nut or cap. The steering gear end has a housing attached to the tube which carries ball sockets and springs. These springs are introduced in the drag link to reduce the shock. The ball end may be introduced through holes in the housing and sockets or through slots which extend to the end of the housing.

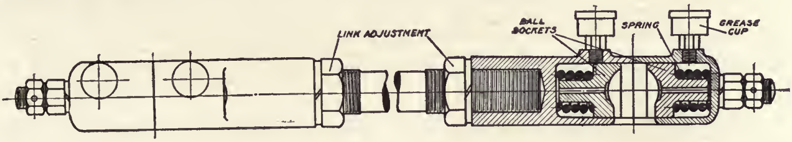

FIG. 183. Vulcan Drag Link.

The Vulcan drag link (Fig. 183) offers an example of the type used on heavy vehicles. This consists of a link of solid section threaded on both ends into housings which are divided on the ball center. The ball sockets on both ends are provided with cushion springs, while the caps of the housings are retained by long studs. This tends to facilitate assembling especially when the springs are heavy.

Some makers enclose these joints in leather boots, as shown in Fig. 179, to hold grease and prevent dirt and grit from cutting the ball surface.

As mentioned previously, universal joints are necessary at both ends of the drag link, because the steering arm moves in a vertical plane, and the knuckle arm in a horizontal plane, but instead of the ball and socket joints, forked joints are sometimes used. This type of joint was illustrated in the preceding chapter. They are somewhat simpler in construction and present larger bearing surfaces. However, they are more difficult to enclose and cannot take up wear automatically.

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CHAPTER XV

MOTOR TRUCK FRAMES

The chassis frame practically forms the foundation of a commercial car, since all the power-transmitting and other units are attached to it. It is often referred to as the backbone of a commercial car. Its construction depends to some extent upon the general scheme of the chassis layout, the construction of power-transmitting units and their mounting, as well as the method of final drive, wheel base, etc.

When the commercial car was first introduced, comparatively little attention was paid to the frame, as other things such as the power plant, axles, etc., were deemed of greater importance, hence the frame received slight consideration. However, after experiencing considerable difficulty, due to accidents and other failures which were traced directly to poor frame construction, commercial car builders discovered that frames could be designed with greater strength and with less weight if the problem was given proper consideration.

Unit Power Plants and Flexible Mounting.—The constant trend of obtaining perfect alignment for the engine, clutch and transmission has resulted in the adoption of the unit power plant on some models, while in others, particularly of the heavier type, flexible mounting of the units has been resorted to. In fact, regardless of unit construction, all individual units are generally flexibly mounted to some degree, in order to relieve them of the heavy stresses due to frame weaving when the road wheels mount an obstacle on the road surface. However, since this subject of power plant mountings is of considerable importance, this will be discussed in detail in the succeeding chapter, the author confining this chapter to the construction of the frame. In discussing this subject, it may be necessary in some cases to refer to the general chassis construction in order to clearly depict each type.

The most prominent types of truck frames may be divided into three classes, according to their popularity: (1) The pressed steel frame, (2) the structural channel frame, (3) the structural I-beam frame. These may again be divided into various classes, depending upon the general construction and material as well as the distribution of the main units.

The Pressed-steel Frame.—The pressed-steel frame is quite popular on all types of vehicles and is now universally used on vehicles up to and including those of 5-ton capacity. Structural channel and I-beam frames are still used by a number of makers; however, the pressed steel frame is rapidly gaining favor and from present indications will eventually replace the other types.

In discussing the advantages and disadvantages of the various types, the pressed steel frame may be mentioned as being lightest in weight for equal strength of the structural or rolled channel and I-beam section, while its cost is somewhat higher, due to the use of heat treated material to obtain maximum strength. The cost varies with the section, material and the nature and extent of bending.

The straight side rail is of course the cheapest construction; however, when conditions permit, this is usually tapered at the front and the rear and the forward end is sometimes formed to receive the spring hanger. When the seat is placed above the engine this taper is usually very short, permitting the paying load to be carried well to the front. Bumpers are sometimes provided to protect the chassis, these may either be formed integral with the frame or attached to it by castings.

When the side members are inswept to permit a short turning radius, it is necessary to make the flanges of the side rail of considerable width at this point, tapering gradually toward the rear, to provide the proper strength at the point of offset.

Cross Members.—Cross members are usually made of the same material as the side rails and when pressed have integral gussets, this, of course, is not possible with the rolled sections so that the separate gusset plates must be used, thus placing the strain on the rivets, instead of on the cross member.

These frames of either type are used in both flexible and rigid constructions. While both kinds of material are subject to heat treatment, it is generally conceded that pressed steel is a higher-grade metal than rolled stock. Owing to its temper it will stand a certain amount of bending which would give rolled stock a permanent set or crack it. It is alleged that pressed steel is more sensible to vibration, in that it will crystallize sooner than rolled steel under similar conditions. Instead of being built up rigid, as are rolled-steel frames, the pressed-steel frame may be built up flexible, so that instead of taking the vibration dead, as well as sudden shocks, it gives to them and transmits them to other parts, so that the individual vibrations in any part are reduced by distribution. The pressed steed flexible frame may also be made lighter for its strength because of its flexibility.

The Rigid Frame.—The rigid frame, too, has advantages, whether it is of pressed steel or rolled stock. It permits the body to be secured rigidly to it and as it does not give to the inequalities of the road, there is no racking of the body. An advantage of rolled stock is its cheapness, except of course in the lighter models of the assembled type for which frames can be purchased at low figures. Another advantage of rolled stock is the ease with which the wheelbase can be altered. The maker using this type of frame may with little additional expense give customers a shorter or longer frame than standard.

It is possible to alter the pressed-steel frame in length by cutting off from the maximum length, although this disturbs the nice proportioning of the frame for stresses, one of the important advantages of this type.

Effect on Springs.—The effect of frame construction upon the design and duty of the springs must also be considered. This feature is not generally understood, but has an important bearing

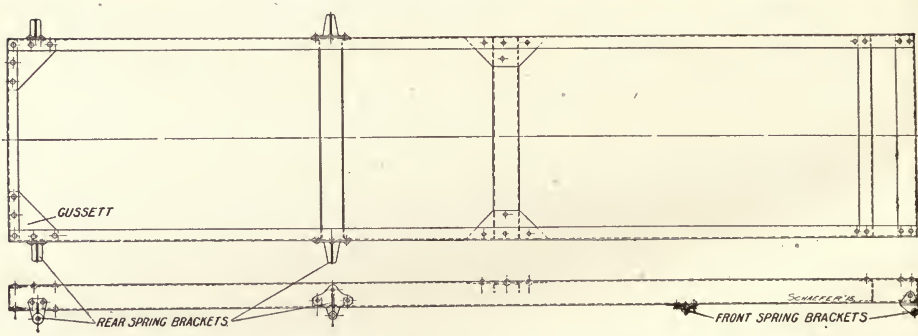


FIG. 184. Vim Delivery Car Frame.

upon the life of the vehicle. A rigid frame relies upon the springs to allow for all axle displacement. If the front and rear wheels on opposite sides be raised several inches simultaneously, the frame is subjected to a torsional stress. If the frame is rigid, springs of considerable camber must be employed in order to absorb the shock without being bent past the limit of safety and sufficiently flexible to absorb all of the shock without any tendency to lift the other wheels from the ground. For this reason a different type of spring is used on a rigid chassis from that used on flexible ones.

The flexible frame when diagonally opposite wheels are raised does not impose all of the duty on the springs, but warps and absorbs a part of the stress. For this reason springs on flexible chassis are usually flat or nearly so, with a reduced amount of play. Flexible construction also permits the frame to be carried equally as low as with the underslung spring, and yet the spring is perched above the axle, where it is more nearly in line with the center of gravity, thus reducing sidesway.

Details of construction such as spring hangers, etc., vary considerably, as can be noted from the descriptions of the various types, which follow:

Specific Illustrations. — The Vim ½-ton frame (Fig. 184) illustrates a construction of pressed steel, with straight side rails and cast spring hangers which are riveted to the former. Owing to its shortness on account of the small size of the vehicle this frame is unusually strong.

The Reo ¾-ton frame (Fig. 185) also employs straight-side rails; however, these are tapered and bent at the front end to receive the spring hanger. This illustration shows in detail all parts

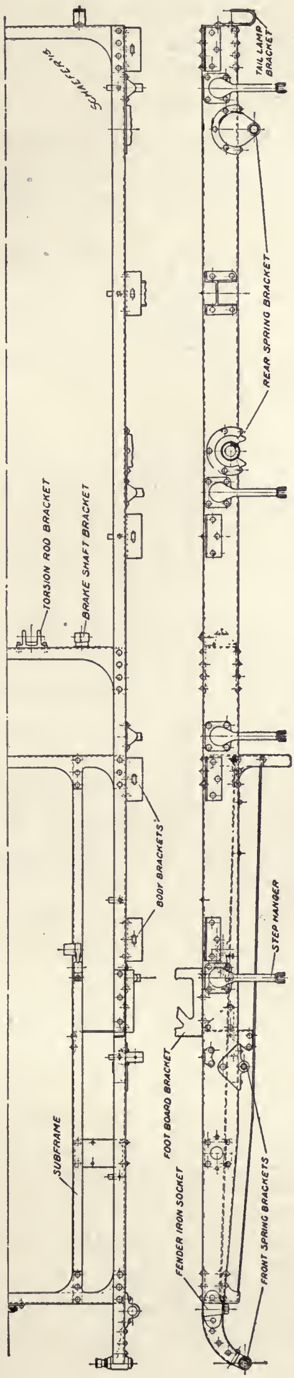


Fig. 185. Reo. Pressed Steel Frame for ¾-Ton Truck.

which are riveted to the frame and also a rigid sub-frame construction, which is set at an angle to provide as near as possible a straight-line drive to the rear axle. All cross members are provided with integral gussets, while pressed-steel parts such as step hanger, body brackets, etc., are used to keep the weight within reasonable limits for this size of vehicle. One-ton frames are built along similar lines.

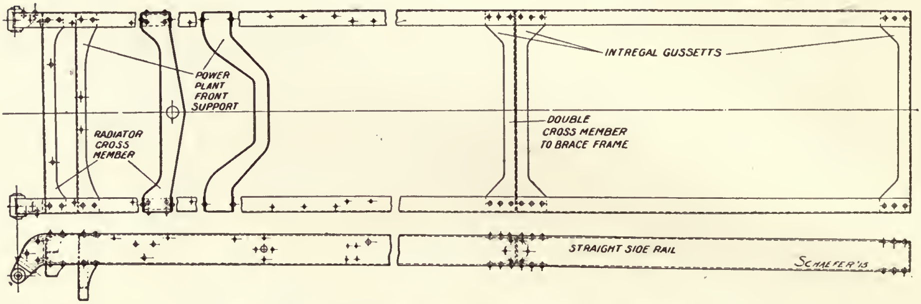


FIG. 186. Fremont Mais Pressed Steel Frame.

Fig. 186 depicts the Fremont Mais $1\frac{1}{2}$- to 2-ton frame, with straight-side members, bent at the front end to receive the spring brackets. In this construction, the scheme is to eliminate unnecessary cross members, so that the frame forms a flexible construction; however, it presents an excellent method of providing strength at the point where the drive, which is taken by the springs, is transmitted to the frame. This is accomplished by placing two cross members together to form an I-beam structure.

Fig. 187 shows the flexible frame construction, which is characteristic of all Pierce worm-drive trucks. The side members are pressed steel and taper at both ends, the front being bent to form the spring hanger, while the bumper is also attached at this point. But two cross members are used, as such parts as the spring brackets and torsion rod support are used for this purpose, while the rear member is of tubular section. A brace of cross shape serves to form a flexible support at the point of drive. In this construction the drive is taken through radius rods attached to a bracket which also forms the spring bracket and carries the tubular member from which the torque arm is supported.

The Locomobile trucks are also also worm-driven and are equipped with radius rods and torque arm to take the torque and driving thrust; however, the frame (Fig. 188) is made of rigid

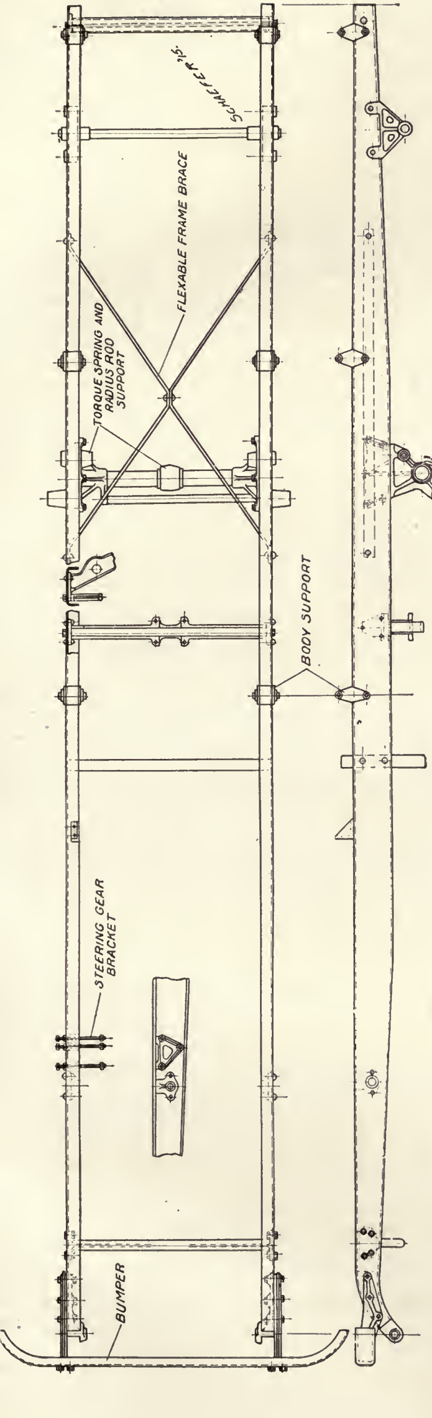


FIG. 187. Pierce-Arrow Pressed Steel Frame Flexible Construction.

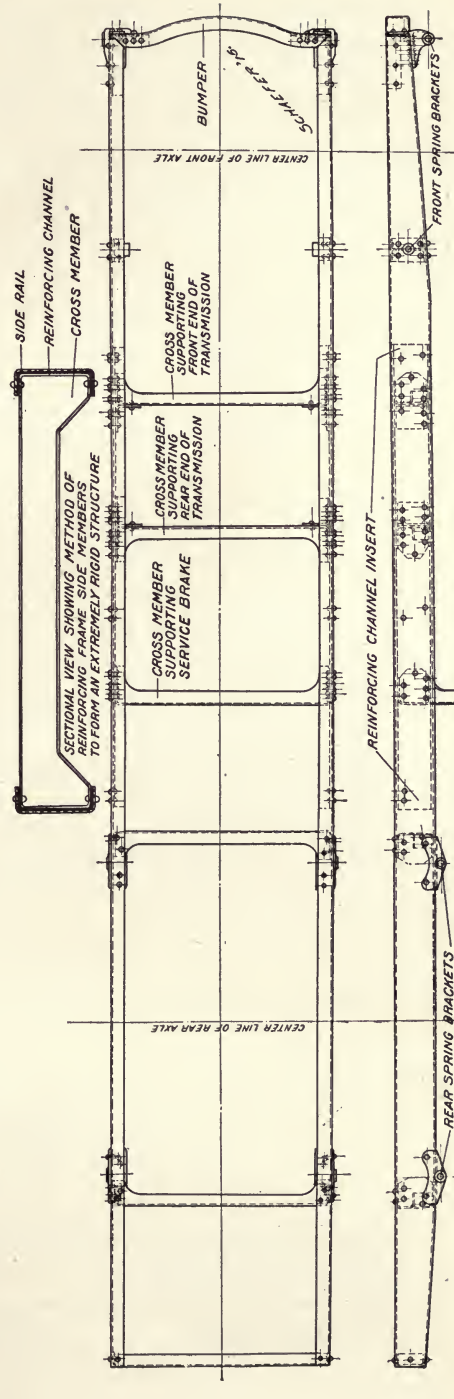


FIG. 188. Locomobile Reinforced Pressed Steel Frame.

construction. It is made of pressed steel with side members tapered at both ends and cast spring brackets riveted to the side rails. The forward cross member forms a bumper, while the remaining members support the transmission and service brake

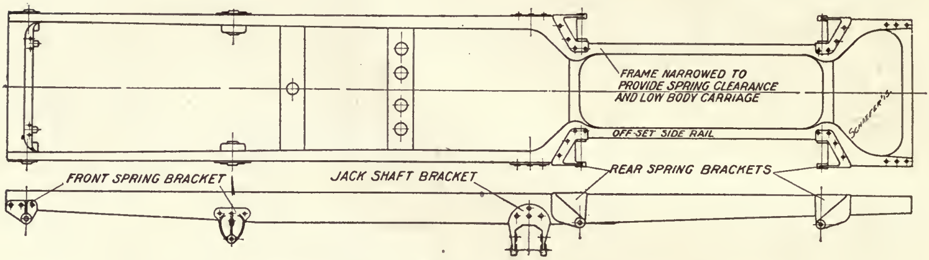


FIG. 189. DeKalb Pressed Steel Frame Inswept at Rear.

and form braces at the points of spring anchorage to the side rails. The extreme rigidity of this construction can be noted by the numbers of cross members and the method of reinforcing the rail with an etxra channel insert.

Fig. 189 depicts the De Kalb 4-ton frame, which is also of pressed steel with tapered side members. This frame is of conventional design with the exception of the side rails, which are inswept along side the rear springs much the same as the conventional side member is narrowed from the dash forward to reduce the turning radius. Through this feature lower body car-

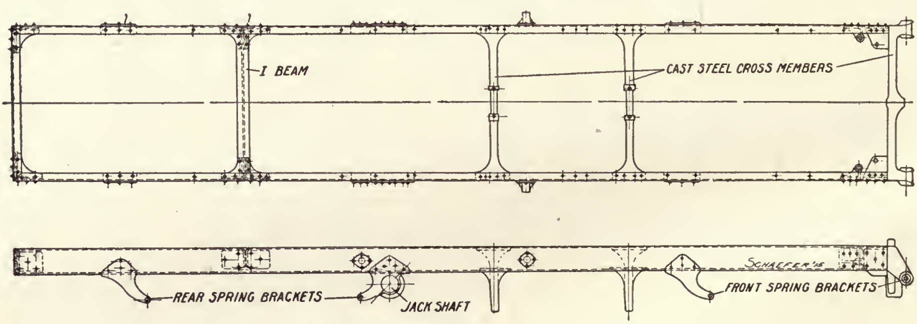


FIG. 190. U. S. Structural Channel Frame.

riage is obtained than would be possible otherwise. It also provides ample clearance for the radius rods, chains and springs. The flange width is increased at the point of offset to provide proper strength.

The United States 3-ton frame (Fig. 190) is an illustration of the structural or rolled channel frame, combined with steel castings and a construction in which each unit is mounted as flexibly as possible. The forward three cross members are steel castings, the fourth of I-beam section rolled steel and the rear of channel shape rolled steel. The front-spring hangers are formed integral with the front cross member, which is in two halves, bolted together at the center.

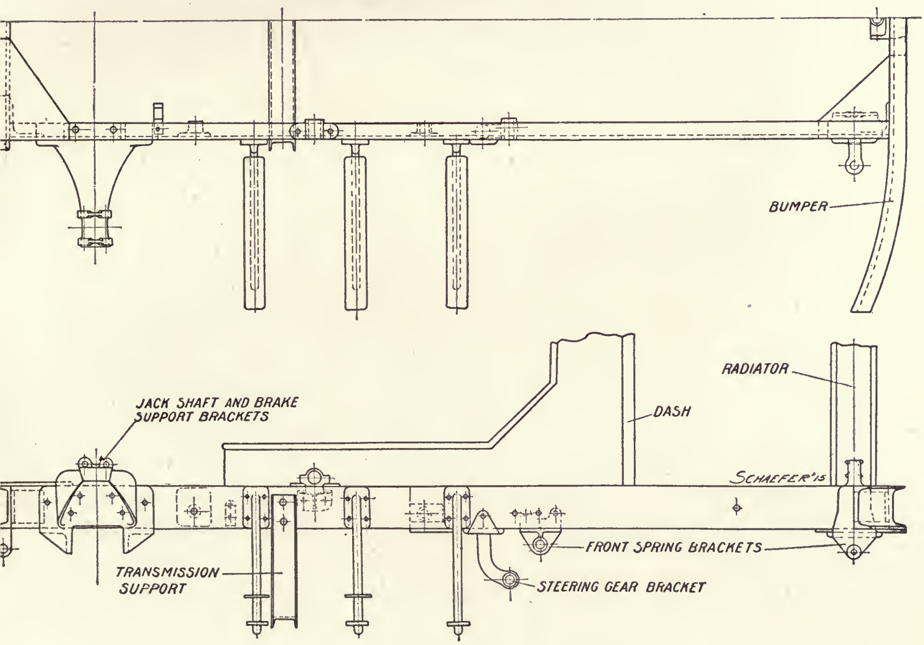


FIG. 191. Knox Tractor Frame.

The Knox tractor frame (Fig. 191) is made from rolled steel of channel shape; however, it is comparatively short, as the rear axle is attached to the frame by means of cantilever rear springs. Thus the frame merely extends far enough to carry the support on which the spring pivots. The illustration shows the combined jackshaft and brake support bracket and other parts which are riveted to the frame. Large gusset plates are used at the front and rear end, while the front cross member extends to each side and is curved to form the bumper.

The 3-ton Velie frame (shown in Fig. 192) is built up from rolled steel of I-beam section, with subframe members of chan-

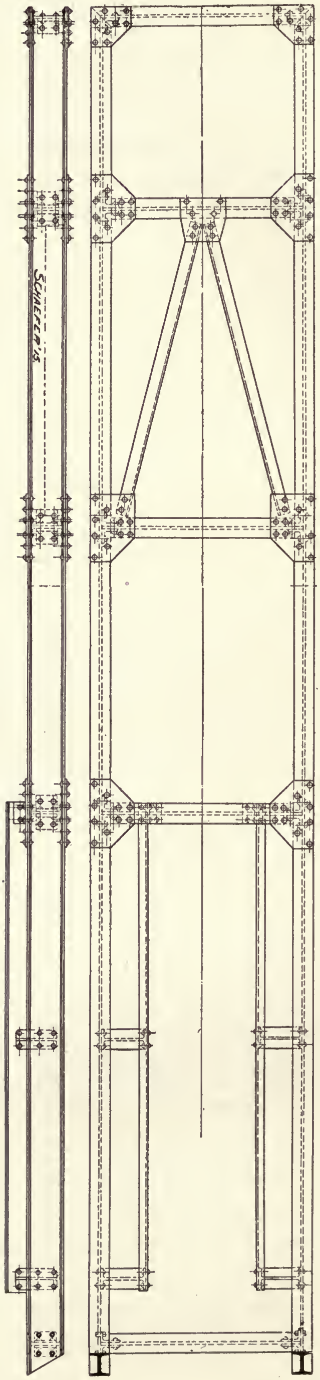


Fig. 192. Velie Structural I-Beam Frame.

nel section. It is of the rigid type well braced, and provided with heavy gusset plates. The front cross member is bolted in position for easy access to the power plant. Diagonal braces of channel section are placed between the third and fourth cross members for stiffening the frame. It is claimed that I-beam section provides a much heavier and stronger frame, due to greater width of the flanges.

To eliminate the braking of frames, there seems to be a general movement against drilling any rivet or bolt holes in the bottom flanges of the side rails. Instead of drilling the flanges in attaching the body and frame brackets, the vertical section of the frame is drilled. There is less weakening of the frame by this process. There is also a decided tendency toward the use of straight-side rails. A novel feature which accomplishes this is used on the Nash trucks and illustrated in Fig. 193. Instead of tapering the frame at the front end as is usual by carrying the top flange straight, the taper is accomplished by keeping the bottom flange straight and tapering the top gradually down to the spring horn. Bolting instead of riveting frame members and castings is also receiving serious consideration at present.

Structural steel of channel or I-beam section is bought from the steel mills in stock lengths. It is usually manufactured from Bessemer steel, afterward subjected to open hearth process in which it is saturated with carbon, to certain specifications for certain uses.

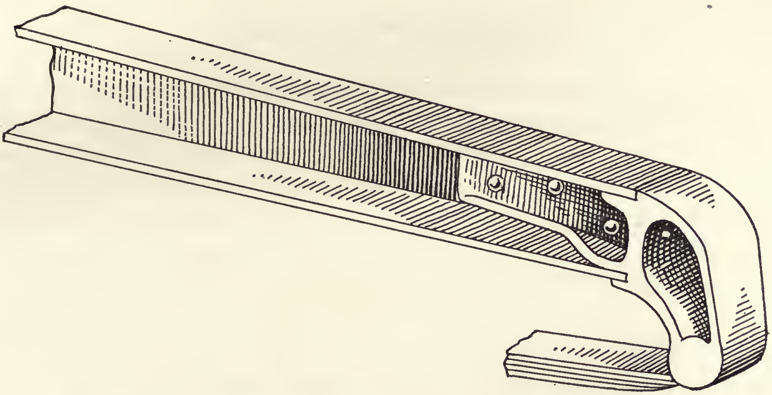


Fig. 193. Nash Frame showing Taper of Upper Flange.

Pressed steel is purchased in sheet form, cut to the proper shape in the flat and then pressed into channel form under great pressure. It is made of steel rolled into sheets; it is made somewhat closer grained, and there is no breaking of the flake in the rolling operation. The pressed steel frame permits of greater simplicity in assembling, since parts can be easily bolted or riveted to it.

CHAPTER XVI

POWER PLANT MOUNTINGS

An interesting problem in connection with commercial car designing which merits careful consideration is that of mounting and arranging the power plant so as to protect it from stresses caused by frame weaving, due to road irregularities. Vibration is another factor of considerable magnitude that must be considered, while provision must also be made for torque reaction.

Power-plant mounting is being freely discussed and there seems to be a general tendency toward some form of flexible support, so that sufficient freedom is given the engine, while others resort to a spring mounting, which combined with a flexible support, protects the power plant from vibration and frame weaving.

Opinions differ greatly as to the correct mounting, some maintaining that the usual method of bolting down the two rear engine arms rigidly to the side rails of the frame does not give the engine sufficient freedom, even if a flexible support is provided at the forward end. Others take the opposite view, claiming that the front flexible support is sufficient. There are also some engineers who claim good results can be obtained by a rigid central support at the front end, as this practically gives a three-point support, and permits frame weaving to be taken up by the cross member which supports the forward end of the engine.

The material give of the cross member should absorb severe stresses and also hold the engine more rigidly against torque reaction.

If the engine is mounted with a pivoted support at the forward end, the torque reaction caused by an explosion in the front cylinder, must be transmitted through the crankcase to the rear engine arms before it reaches the frame. However, if the forward support is of the rigid type, the stress goes to the frame direct.

In addition to the flexible front support, some makers also provide swivel supports for the rear arms, so that all the torque reaction must go to the rear arms, but no frame distortion can by any possibility put a stress upon the crankcase. Larger and more massive engine arms are also being used, thus increasing the efficiency of the present mountings.

Coil springs of considerable strength are also used under the front or rear supports, and these absorb some of the stress created by frame weaving, while they can also be arranged to absorb some vibration.

An important point with a rigid mounting is the method of securing the rear arms to the side rails of the frame. In this case, the engine must be held securely, and the frame must not be appreciably weakened, while the arrangement must be such that the supporting arms can be quickly freed when it is desired to remove the engine from the chassis.

In the unit power plant the transmission is supported from the flywheel housing, but in the amidship position, it is usually mounted on a three-point support, so that it has a certain degree

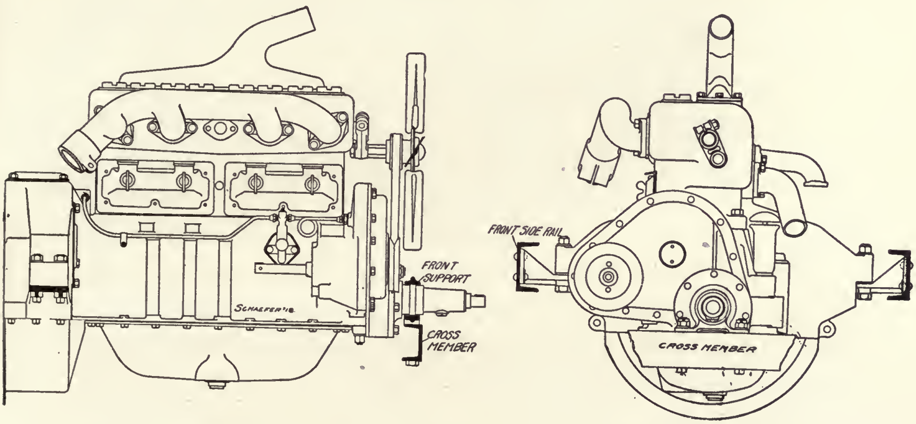


Fig. 194. A Prominent Type of Flexible Support, which may be Adapted to Either the Engine or a Unit Power Plant.

of flexibility to resist frame weaving. In some cases where a flexible subframe is used for the motor, this is also arranged to support the transmission. For midship mounting, cross members of the frame are usually used, so that the forward support forms the flexible member, while the rear carries the two rigid supports.

One of the most prominent types of flexible supports is shown in Fig. 194, which may be adapted to either the engine or a unit power plant. This particular illustration represents the Globe 1-ton truck, equipped with a Continental engine. In this construction two cast arms integral with the flywheel housing, form the two rigid points of support. These are set on hangers, riveted to the side rails of the frame, while bolts pass vertically through both, to hold the power plant in position.

The third point of support is at the front end of the engine, and consists of a bracket fitting over a finished surface, on the hub extension of the gear cover plate. A cross member passes under this, and has the bracket fastened to it by two bolts.

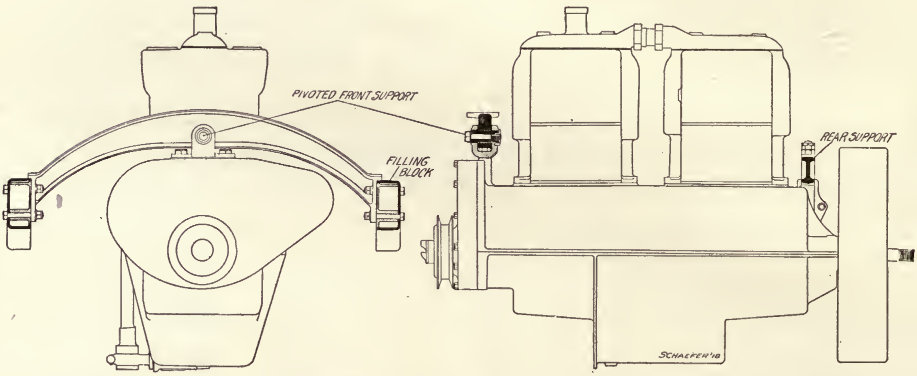


FIG. 195. A Three-Point Main Frame Mounting Employed on the Riker Trucks.

This engine is also used on the Denby trucks, and is mounted in a similar manner, but in order to provide more flexible rear supports, one bolt on each side is fitted snugly and provided with a coil spring, the others being a loose fit.

Another type of three-point mainframe mounting is shown in Fig. 195, being employed on the Riker commercial cars. In this construction, a heavy drop forged member is attached to the crankcase at the rear by studs, which pass clear through the case. These studs are so close together that considerable freedom is obtained by this supporting member, through the elastic extension of the studs, and the elasticity of the forged member. The forward end is also supported by a forged member; however, this is pivotally arranged in a bracket bolted to the crankcase. Metal filling blocks are fitted into the side rails of the frame, and three bolts in each end of these supports secure the engine to the frame. The top flange of the supports overhangs the filling blocks, and so relieves the bolts from the weight of the engine.

The Pierce 5-ton truck engine is also mounted in a similar manner, while the Packard truck engines have a pivot mounting at the front end, and the rear end is supported by a large member which is bolted to the flywheel housing.

An interesting and simple method of support is used on the Union trucks (Fig. 196), which is covered by patent. The forward support is of swivel type, consisting of a bracket fitting over a hub extension of the timing gear cover. This bracket has

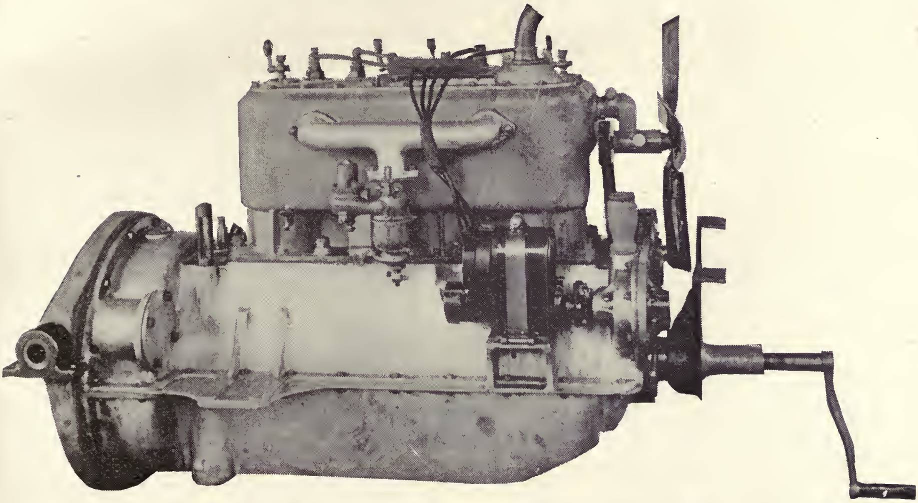


Fig. 196. Simple Method of Support used on the Union Trucks.

two lugs which rest on the upper flange of the cross member, so that the weight is taken off the bolts that hold the bracket in position.

The rear support is a large cast member bolted to the flywheel housing, which has a trunnion formed on each side, and these fit into brackets, that in turn are bolted to hangers riveted to the frame side rails. This gives the engine somewhat greater freedom, and permits taking the torque reaction on the rear member.

The Signal truck has an unusual engine mounting (Fig. 197), which is also covered by patent. In this construction, swivel supports are also used on the rear arms, for with such a layout the torque reaction must all go to the rear arms, but no frame distortion can by any possibility put a stress upon the crank case. A bracket developed into spherical shape is bolted to the arms extending from the flywheel housing and supported by brackets bolted to the frame members. The forward support is of the pivoted type, similar to the Riker, having a drop-forged member that is supported by coil springs and brackets attached to the

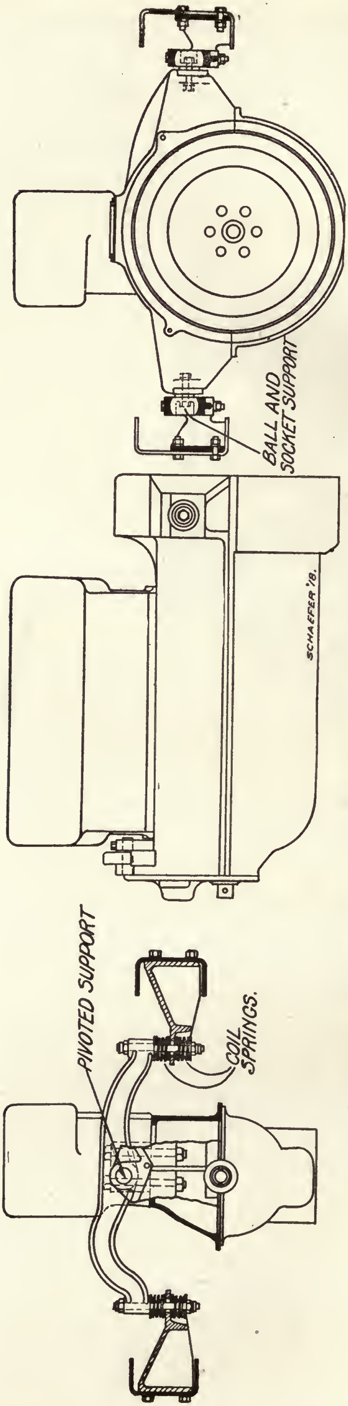


Fig. 197. Three Views of the Patented Mounting on the Signal Truck.

frame members. A long stud supports the springs above and below the frame brackets, so that the springs relieve the engine of severe shocks and vibration.

The Diamond T-trucks also have a swivel rear support of the ball-and-socket type, and the front support is of the pivoted type, supported from a channel section cross member, which is also used to support the radiator.

One of the chief difficulties encountered in combining the engine and transmission in a single unit is due to the fact that the flywheel is located between them and to enclose it requires a great deal of metal, adding both to the weight and the cost. In commercial car practice the four-cylinder engine seems to have become the standard and with these there is a tendency to use a flywheel of inadequate capacity, when it is to be enclosed, which detracts somewhat from the steady running qualities of the vehicle. To overcome this, two expedients may be resorted to. One is to place the flywheel at the front end of the engine, but there are a number of objections to this practice. The purpose of this flywheel is to equalize the torque of the engine before it is transmitted to the transmission and its logical place therefore seems to be between these two units. The forward location also places it in a position where it can easily be injured, while the strains on the tires are increased and the clearance between the engine and front axle is materially reduced.

On the Dorris commercial cars all the features of an open flywheel are retained as illustrated in Fig. 198, by joining the engine and gear box by a large yoke which permits the use of a large flywheel and also affects a considerable saving in weight.

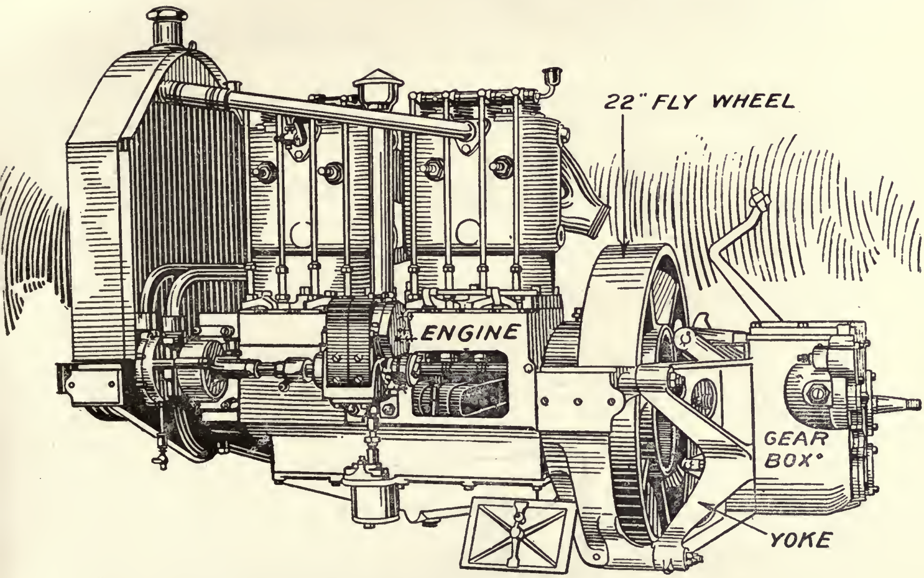


Fig. 198. The Dorris Unit Power Plant.

The method of mounting the engine in the United States motor trucks is illustrated in Fig. 199. The engine is mounted on a subframe, the front cross member of which extends into the side members of the frame. This cross member has ends that form a yoke into which are placed heavy coil springs, retained by a long bolt, passing through a bracket riveted to the frame, thus utilizing the springs to absorb severe shocks and vibration.

A 5-in. spherical bearing riveted to the rear of the subframe forms the rear support. This rests on a large cast cross member, which is dropped considerably at the center. The support is on the upper side of this cross member, thus providing a very flexible mounting.

The larger sizes of Kissell Car trucks also have the power plant mounted on springs at both ends, with provision for flexible mounting incorporated in the rear supports as depicted in Fig. 200. The engine is mounted upon a pressed steed subframe having cross members at both ends, which are dropped consid-

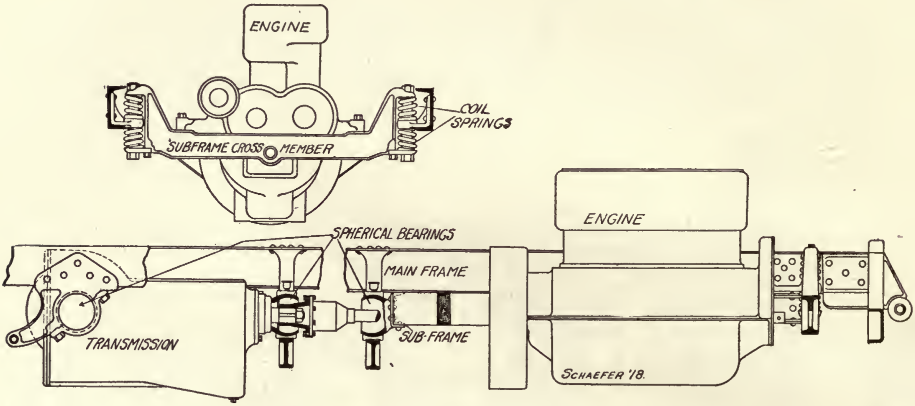


FIG. 199. Sub-Frame Arrangement used on the United States Trucks.

erably at their center. The front cross member has two pressed steel brackets which rest on heavy coiled springs placed inside

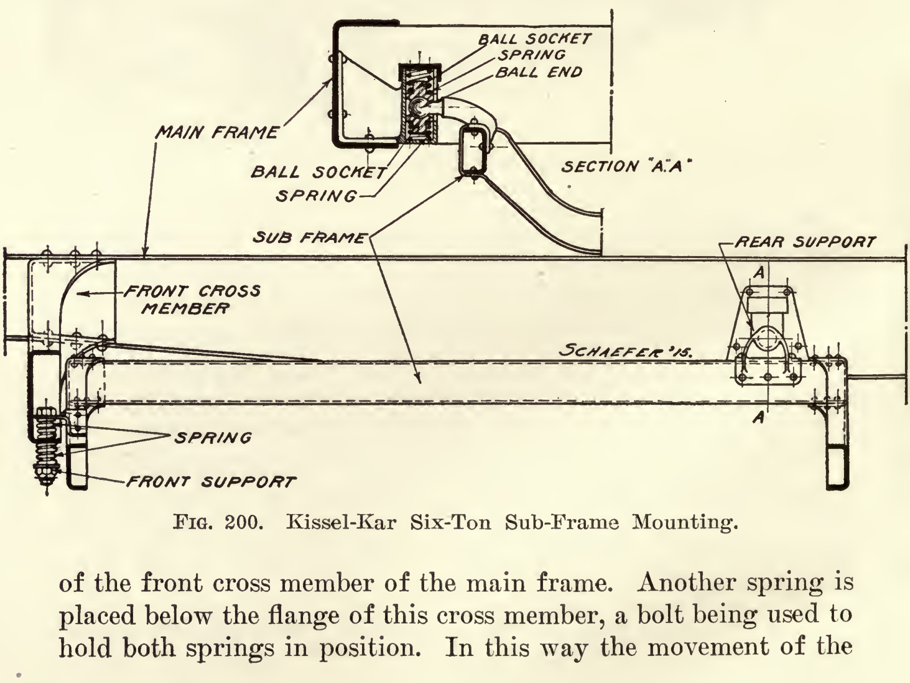


FIG. 200. Kissel-Kar Six-Ton Sub-Frame Mounting.

of the front cross member of the main frame. Another spring is placed below the flange of this cross member, a bolt being used to hold both springs in position. In this way the movement of the forward end of the subframe is controlled in both directions. The rear support is formed by brackets riveted to the subframe members, which have a ball-shaped end that rest on ball sockets placed within a bracket riveted to the main frame members. These ball sockets are provided with springs, to relieve the power plant of shocks due to vibration while the ball permits a certain degree of flexibility when the frame twists. In reality this is a four-point suspension which retains all the features of a three-point suspension.

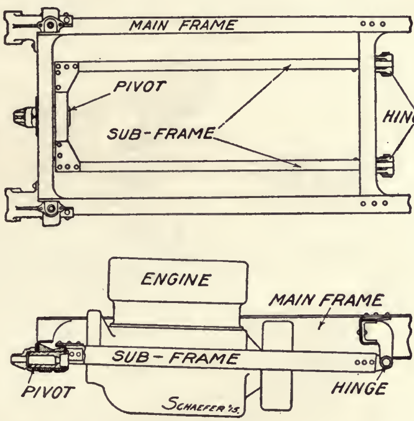


FIG. 201. Mogul Power-Plant Mounting.

The same principles of unit power-plant mounting may be applied to vehicles in which the engine or both engine and transmission are carried on a subframe. Fig. 201 illustrates this feature applied to Mogul trucks. The frame has a front cross member which carries a bracket to form the bearing for the third point of support. The subframe is also provided with a cross member and a bearing bracket, so that a hollow pin can be inserted. This is retained by a large nut, having a hub, which together with the pin forms the bearings for the starting crank. The rear ends of the subframe being supported from a frame cross member.

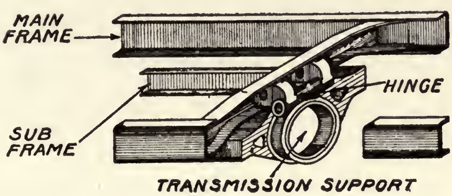


FIG. 202. Three-Point Suspension of the DeKalb Sub-Frame.

A similar construction (Fig. 202) is used on the Dr. Kalb commercial cars. However in this case the hinge is placed at the front end of the subframe members, while the rear end has a large drum which forms a single hinge. Fig. 203 illustrates a sectional view of this rear support and also illustrates the method of supporting the front end of the transmission from this point. The transmission is bolted to the jack shaft and has a long torque tube extended to this third point of support, which is of spherical form.

The principle of three-point suspension in the Blair trucks (Fig. 204) is even carried on to the rear axle. In this construction the subframe is hinged to the main frame in front by steel castings and heavy hardened and ground steel pins. At the rear it is hinged at right angles to the worm-drive-axle housing. It is claimed that this system renders the subframe that carries the power plant flexible to any position, maintaining perfect alignment in the transmission of power. It provides a straight-line drive under all conditions, and almost entirely eliminates universal joints in the drive.

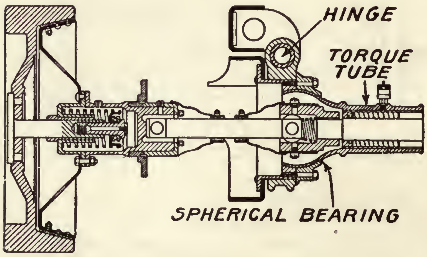


Fig. 203. DeKalb Sub-Frame and Transmission Support.

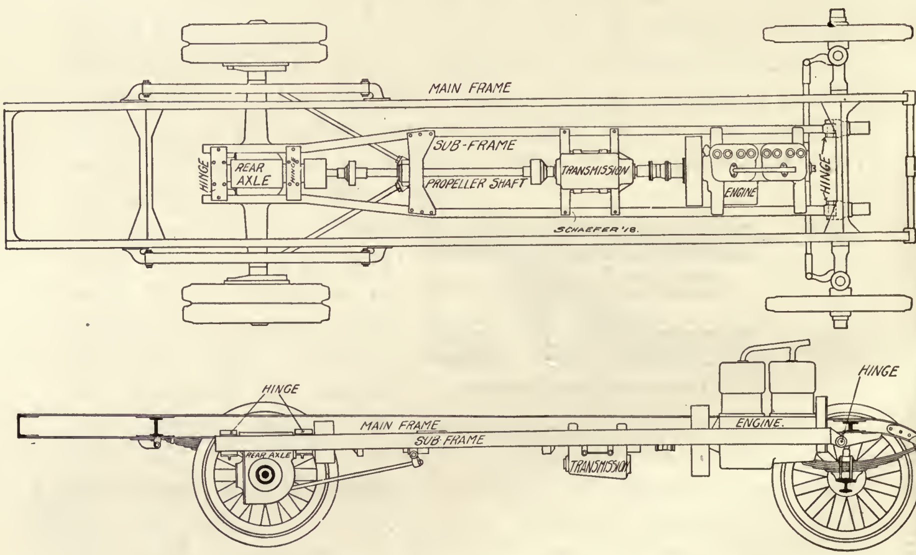


Fig. 204. Sub-Frame Arrangement used on the Blair Trucks.

Flexible mountings are also applied to transmissions when these are located amidship. An excellent example of this is the United States mounting (Fig. 199), in which spherical or ball-and-socket joints are used at three points, one at the forward end, and one at each side in the rear over the jack-shaft housing.

On the Packard trucks the transmission (Fig. 205) is supported by two pressed-steel cross members. The forward end is bolted to a cross member, which has a machined surface that fits over the housing, which supports the forward or main shaft of the transmission. The rear end is free and pivotally mounted in the brake anchor, which is attached to the cross member.

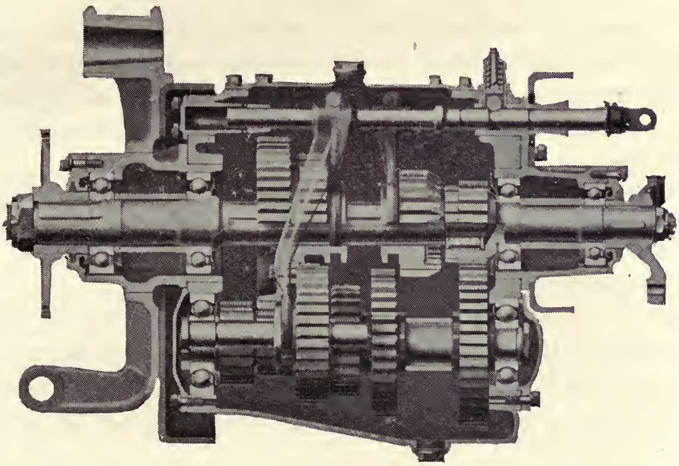


Fig. 205. Method of Supporting the Transmission on a Packard Truck.

On the Federal truck a modified three-point support is used. The transmission case has four lugs, two at each end, and these support the transmission case, being attached to two cross members. The two lugs at the front are close together, and practically produce the same effect as a single point.

Three-point support is also used on several other trucks, the forward support being of the pivot type while the rear is either directly mounted from a cross member or by brackets attached to the transmission.

The advisability of providing a long life for the power plant will be endorsed by all users of commercial cars, and since this feature can be accomplished with little added expense, it would seem to be a step toward reducing maintenance cost. There are very few makers at present who do not provide a certain degree of flexibility in the mounting of their power plants.

These few contended that there is little to be gained through this feature; however, it is not to be denied that for commercial cars, this feature presents several advantages.

CHAPTER XVII

SPRINGS AND SPRING SUSPENSIONS

Commercial car bodies are mounted upon the chassis frame, the latter being supported on the axles through the intermediary of steel springs. These springs are built up of a number of plates varying in length and are used exclusively to support the body, although coil springs are used as auxiliaries.

The upper leaf of this spring usually has an eye at each end for connection to spring brackets on the frame, or shackles. In some few cases the ends are left flat and fit in brackets so that the frame rests directly on them. The balance of the spring consists of a number of shorter leaves, the lengths of which decrease uniformly, except in cases when they are required to carry very heavy loads, in which the first two or three leaves are of the same length. The various leaves are held together by a center bolt or a band.

The method of frame connection depends upon the type of spring and various other factors, while the axle connection is usually made by box clips and a spring seat on the axle. This seat is sometimes called a perch, and may be formed integral, or attached to the axle.

Spring Types.—The simplest type of spring is the semi- or half-elliptic type, while all other types are made up wholly or in part of the former. They may be termed combinations of the semi-elliptic type.

The three-quarter-elliptic type consists of a semi-elliptic lower member and a quarter-elliptic top member. These two members are joined by shackles and bolts at one end. This type of spring is used on pneumatic tired vehicles only at present.

The full-elliptic spring consists of two semi-elliptic members joined at both ends by bolts or shackles and bolts.

The three-quarter platform spring consists of two semi-elliptic side members and one semi-elliptic cross member, the side members being joined to the cross members by shackles and bolts. This type is ordinarily termed the platform spring, since the true full platform spring consisting of two side and two cross semi-elliptic members is not adaptable to the ordinary chassis construction.

Auxiliary springs consist of a half-elliptic with plain ends. The cantilever spring carries the weight at its small end and may either be quarter-elliptic; in which the big end is secured to the frame or a semi-elliptic; in which case it has a pivot support on the frame at or near its center, and is connected to the rear axle at its rear end.

There are also various other combinations; however, they are not employed at present, and consequently are not within the scope of this work.

Semi-elliptic a Favorite.—Regardless of capacity, the semi-elliptic suspension is a decided favorite. It is simple, and if the length, width and other dimensions are proportioned correctly, nothing better than the semi-elliptic spring for front and rear suspension could be desired.

The remaining spring suspensions employed at present may be classified as follows: Semi-elliptic front, full-elliptic rear; semi-elliptic front and three-quarter-elliptic rear; full-elliptic front and rear; semi-elliptic front and three-quarter platform rear; full-elliptic front and platform rear.

Another point worthy of note is the substitution of the true sweep spring and the elimination of the double sweep spring. Having a simple curve, the true sweep spring is easy to fit, and spring makers recommend them on this account. The double sweep spring is simple to mount and has a legitimate place on every truck as an auxiliary or overload spring. Comparison of these two types may be made by referring to Figs. 206 and 207, the former being a true sweep and the latter a double sweep spring.

Until recently, very few springs were equipped with bumpers; however, in most cases these are in the form of coil springs, and on some vehicles they are made of a heavy square section.

The general construction of the various types can readily be understood by referring to accompanying illustrations; however, the method of frame suspension and axle mounting warrants discussion.

De Kalb Springs.—Fig. 206 illustrates the De Kalb rear spring, which is of the semi-elliptic true sweep type. These are placed outside of the frame to permit carrying the frame low, and the main leaf has an eye at each end which is connected to the frame by means of shackles and bolts through brackets riveted to the frame. All bearing surfaces are provided with removable bushings and grease cups. The leaves are held together by means

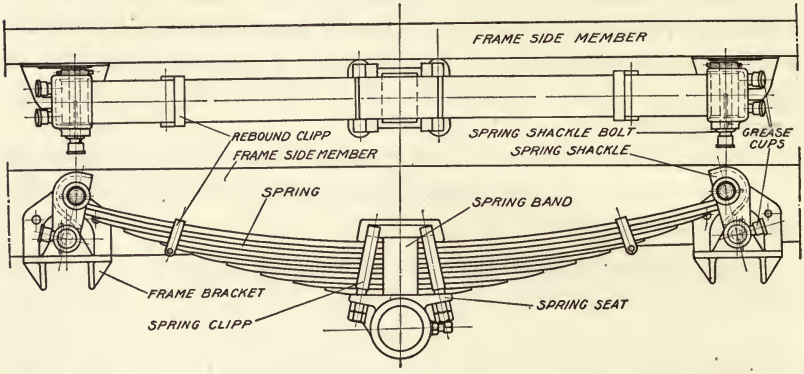


Fig. 206. DeKalb Spring Mounted Outside of Frame and Over Axle.

of a steel outer band which is shrunk over them. The spring is attached to the axle by means of a spring seat which is mounted on the axle spindle and prevented from turning by a set screw. Box clips of square sections, placed at an angle are used to hold the spring to its seat. Two nuts are used to hold the spring rigid, while the upper ends of the clips are held in position by a pres-

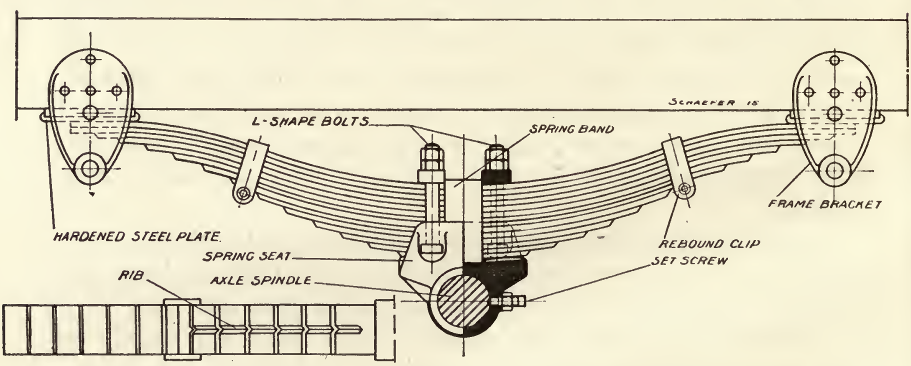


Fig. 207. Mogul Six-Ton Rear Spring with Plain Ends Showing Method of Mounting on Axle.

sure block on the top of the spring which fits snugly over the center band.

The front spring is of similar construction; however, the front end of this is attached directly to the front bracket, while the rear end is shackled to its bracket. The necessity of directly connecting the forward end of a front spring to frame is due to the fact that this is the only connection between the frame and the axle, the spring being utilized to hold the front axle in position. This is also true of the forward end of a rear spring when the torque and driving thrust is taken through the spring. This feature was explained in a previous chapter on the final drive.

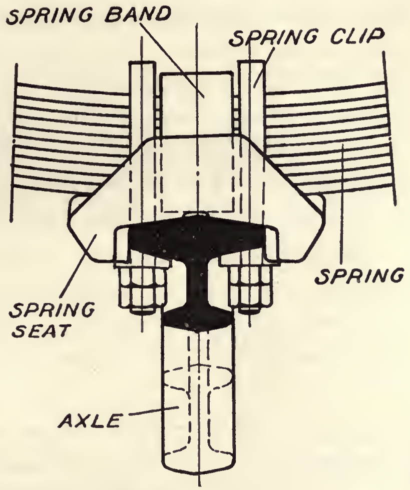


FIG. 208. Mogul 6-Ton Front Spring Mounting.

Mogul Springs.—In Fig. 207 is shown the Mogul 6-ton rear spring, which is of the semi-elliptic double sweep type with plain ends. These ends fit between the webs of the frame bracket, which has a hardened steel plate resting on the spring. In this case the spring seat is also mounted on the axle spindle; however,

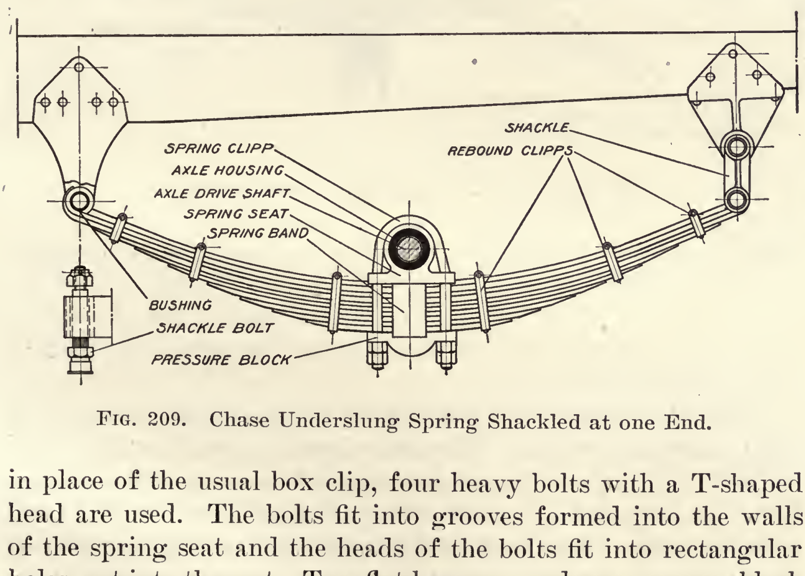


FIG. 209. Chase Underslung Spring Shackled at one End.

in place of the usual box clip, four heavy bolts with a T-shaped head are used. The bolts fit into grooves formed into the walls of the spring seat and the heads of the bolts fit into rectangular holes cast into the seat. Two flat bars are used as a pressure block and are retained by washers and nuts. The front spring is connected to the frame at the forward end by an eye and a shackle bolt, while the rear end is plain and rests against a hardened plate on the bracket. The method of axle mounting is similar to the rear; however, clips are used in place of bolts, while the spring seat is a steel casting, which fits over the axle as shown in Fig. 208. The clips pass through holes in the seat proper which coincide with grooves cut into the upper flange of the axle. Tapered washers and nuts hold these together.

Chase Springs.—On the Chase worm-driven models, the rear springs (Fig. 209) pass under instead of over the axle, and also take both the torque and the driving thrust. For this reason it is necessary to rigidly connect the front end of the spring to the

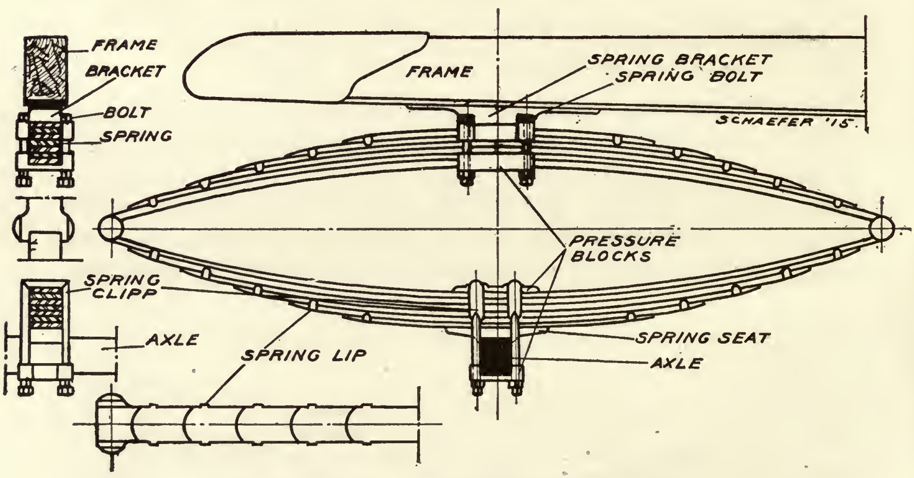


Fig. 210. I.H.C. Full-Elliptic Front Spring.

frame, while the rear end is shackled to compensate for elongation under load. Conditions are reversed in the axle mounting, as the pressure block is placed under the spring and the spring seat over it. These are held together by clips of U-shape which pass over the axle.

Fig. 210 depicts the full-elliptic front spring used on the I.H.C. 1,000-lb. vehicles. They are clipped to both the frame and the axle. This type of spring consists of two semi-elliptic members, one mounted above the other, and are connected at their ends by bolts. This type is also employed on the rear end of these vehicles; however, instead of rigidly connecting the upper member to the frame; this is pivoted on a shaft as shown in Fig. 211. A bracket is attached to the frame, through which the shaft passes. The upper spring seat pivots on this shaft and has the spring clipped to it as shown. The object of pivoting the upper end of the rear spring is to compensate for the spring play since the only connection between the axle and frame with this type of spring is through the radius rods.

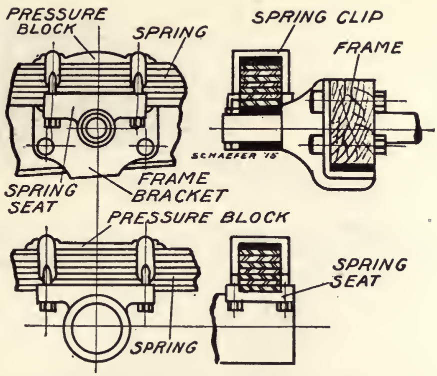


Fig. 211. Method of Mounting I.H.C. Full-Elliptic Rear Spring.

Mack Springs.—Fig. 212 illustrates the three-quarter platform rear springs used on the heavy duty Mack trucks. The rear ends of the two side members are connected by double shackles consisting of two substantial U-shaped members which are hooked together, the same as on numerous horse-drawn vehicles.

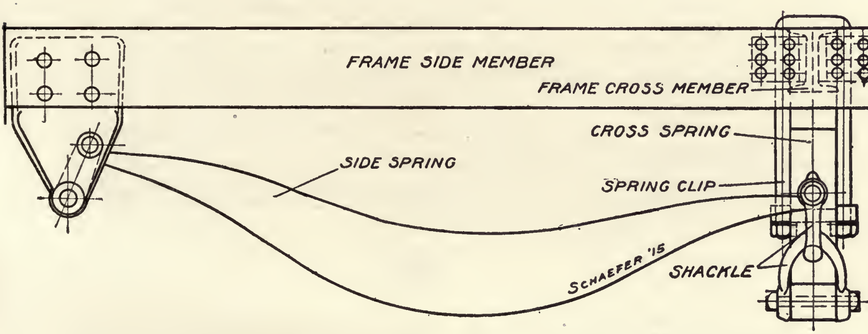


Fig. 212. Three-Quarter Platform Spring used on Mack Heavy-Duty Trucks.

Fig. 213 illustrates the overload or auxiliary spring which is usually a semi-elliptic member of the double sweep type. It is attached to a frame cross member at the center and the ends are free so that they may make connection with a separate spring when a predetermined load has been applied.

On the International Harvester Company's trucks, auxiliary springs are provided which take action at a time when the main springs are about to be overtaxed and prevent the load from coming in dead contact with the axle. These auxiliary springs are of the quarter-elliptic type and are attached to the brackets which take the driving strain at the front end of the spring. The

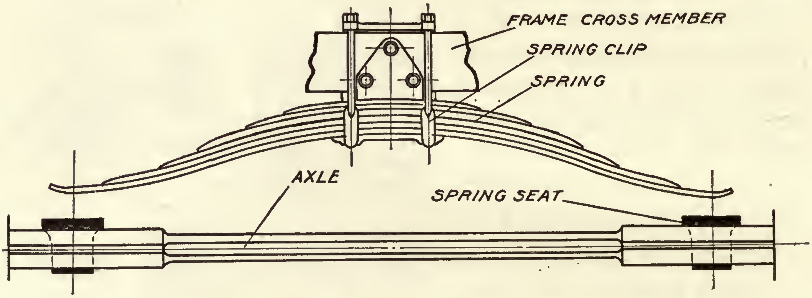


Fig. 213. Overload Spring with Separate Seat.

rear ends of these auxiliary springs are free to bear on the pressure blocks of the rear springs. This construction is illustrated in Fig. 214.

Knox Tractor.—The Knox Tractor employs an unusual method of suspension, Fig. 215, which combines a cantilever and semi-elliptic spring at the rear end of the frame. Heavy semi-elliptic springs are attached to the rear axle with long clips and carry the fifth wheel of the trailer. There is no connection between these and the tractor frame, so that they carry the weight

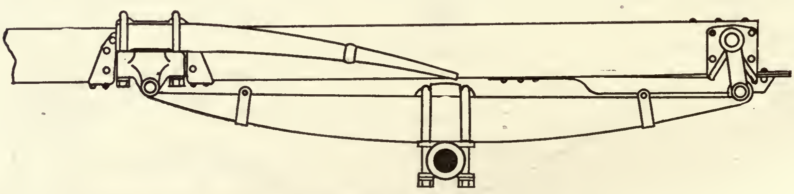


Fig. 214. I. H. C. Quarter Elliptic Overload Spring.

of trailer and load only. The tractor frame is mounted on a cantilever spring, having a pivot near its center and a shackle at the front end. The rear end bears on a seat clipped to the rear axle. This construction permits a flexible mounting for the tractor, and also the carrying of very heavy loads on the trailer.

There is a great variety of methods of attaching the springs to the frame and rear axle. Several methods have been illustrated above, while the following gives an excellent idea of the attention that is being devoted to this vital point.

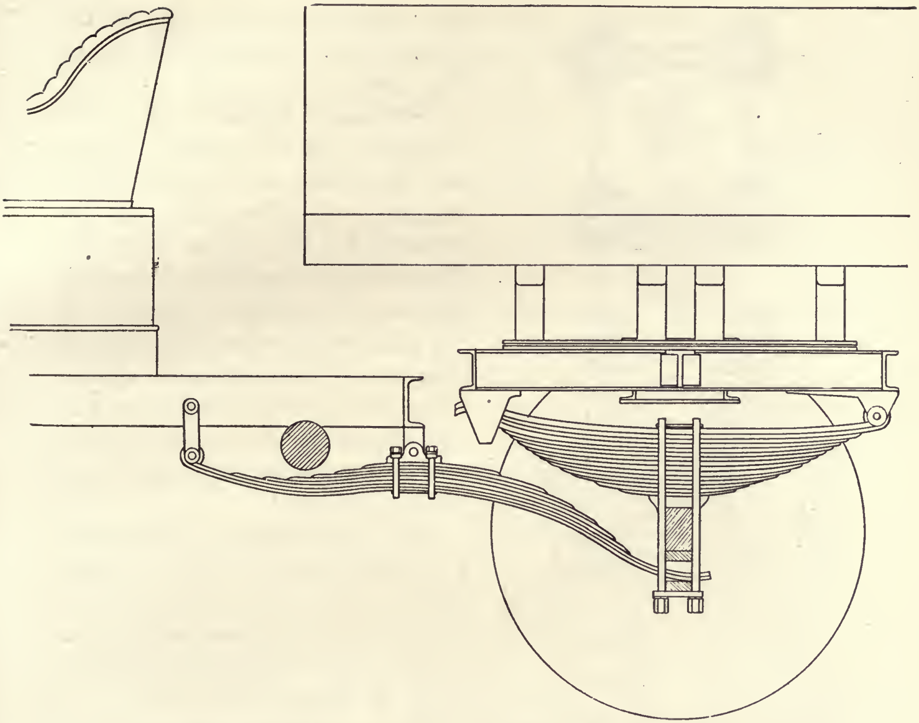


FIG. 215. Knox Tractor Cantilever Rear Spring.

Selden Construction.—The Selden construction (Fig. 216) has a heavy pressure block which is grooved to take the U-shaped clips and carries a heavy coiled spring which contacts with a bracket riveted to the frame and acts as a check for excessive deflections. Two of these coiled springs are used one on each side.

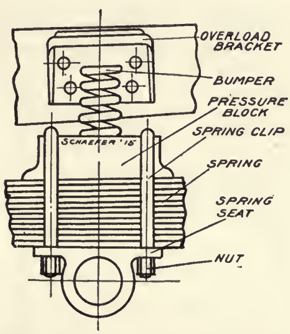


FIG. 216. Selden Spring Mounting.

The Vulcan 5-ton front springs (Fig. 217) are mounted on a seat forged integral with the front axle, and are retained by long studs which have a shoulder near their center and by a drop-forged pressure block.

The Velie 3-ton vehicles have a rear axle of round section and cast spring seats which are held in position by a heavy bolt passing through the axle. The spring leaves are held together by a center bolt which passes through the pressure block. Long

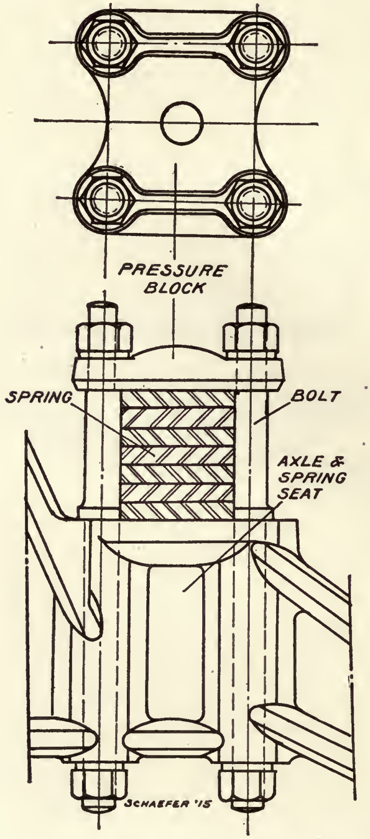


FIG. 217. Method of Mounting Vulcan Five-Ton Springs.

box clips are used to attach the spring to its seat, as shown in Fig. 218.

Peerless Springs.—On the Peerless trucks the front springs are mounted on a seat forged integral with the axle, and are retained by box clips. Fig. 219 illustrates this, and it will be noted that a coil spring is attached to the pressure block which acts as a bumper. Under excessive deflections these springs strike the bottom flange of the frame and arrest the rebound motion of the vehicle springs.

The Nash Quad also employs a spring bumper which is made of flat metal and is termed a volute spring. This is attached to a bracket fastened to the pressure block, as shown in Fig. 220.

The Garford worm-driven models have the springs mounted outside the frame and the bumper springs, which are of square section are mounted directly under the frame side. The vehicle springs are retained by U-shaped clips and a heavy pressure block,while the seat for the bumper is also retained by the clips. This construction is shown in Fig. 221, while Fig. 222 illustrates the spring shackles and the method of connecting these to the frame. This shackle is suspended on a very large shaft extending the full width of the frame and supported by brackets riveted to the frame.

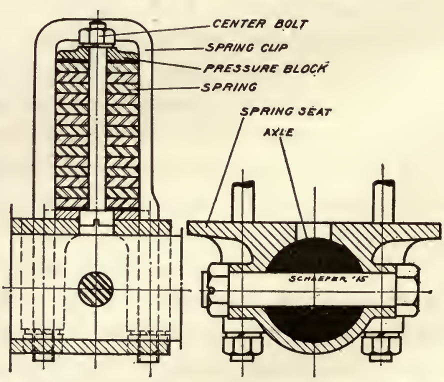


FIG. 218. Velie Three-Ton Rear Spring Mounting.

On the Selden trucks this shaft is replaced by a steel tube which ties the brackets together but the shackle is mounted on a separate stud.

In the Hotchkiss drive, when the springs form the only connection between the frame and rear axle and the drive is entirely dependent upon the main leaf of the spring, there is danger of spring breakage which will disable the vehicle. In order to overcome this disadvantage the Fulton and Garford companies provide a three-point shackle at the front end of the spring, as shown in Fig. 223. This illustrates how the main leaf is supplemented by the elongated eye in the second leaf in caring for the driving stresses, which also illustrates the method of causing the third and fourth leaves to help to assist the two main leaves in bearing the load.

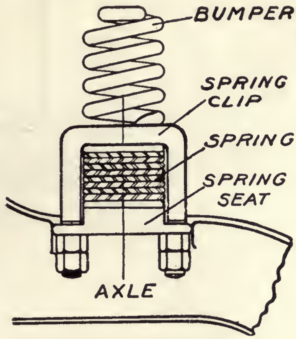


Fig. 219. Peerless Front Spring Bumper and Integral Spring Seat.

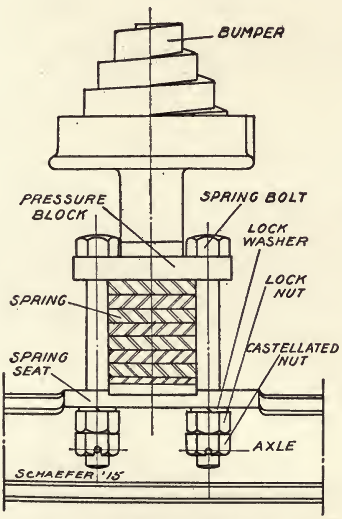


Fig. 220. Nash Quad Spring Mounting and Spring Bumper.

Rebound Clips.—In most cases the vehicle springs are equipped with rebound clips, the purpose of these may be explained as follows: When the road wheel strikes an obstacle in the road, the spring near it is compressed, whereby energy is stored up. Immediately after the compression has ceased the spring extends again, and if the blow was a heavy one the rebound will carry the body far beyond its original position. This rebound has a tendency to curve the main leaf of the spring in the reverse direction, and in order to prevent any serious difficulty it is necessary to transmit this shock to several of the leaves. This is accomplished by the rebound clips which are riveted to the shortest leaf which they surround and connected over the main leaf with a bolt.

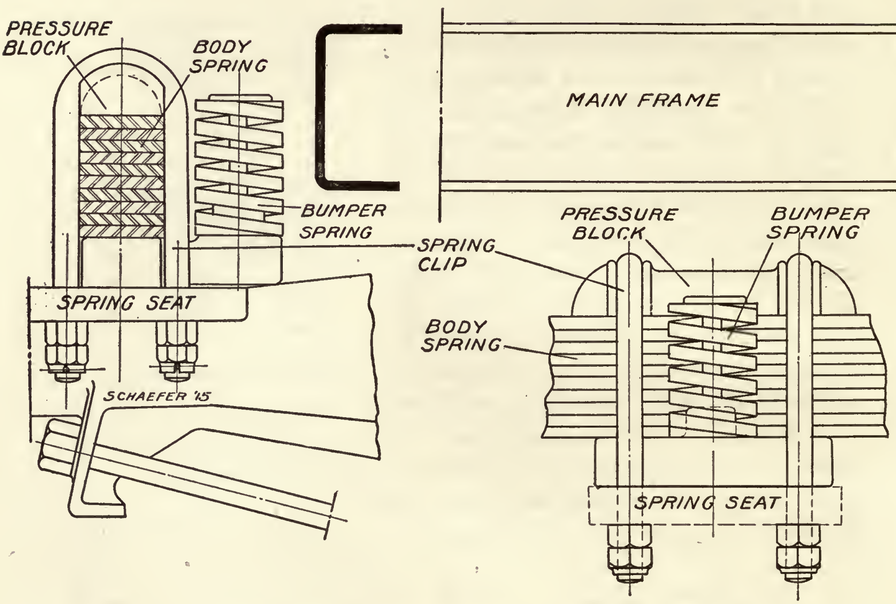


Fig. 221. Method of Mounting Springs on the Garford Trucks.

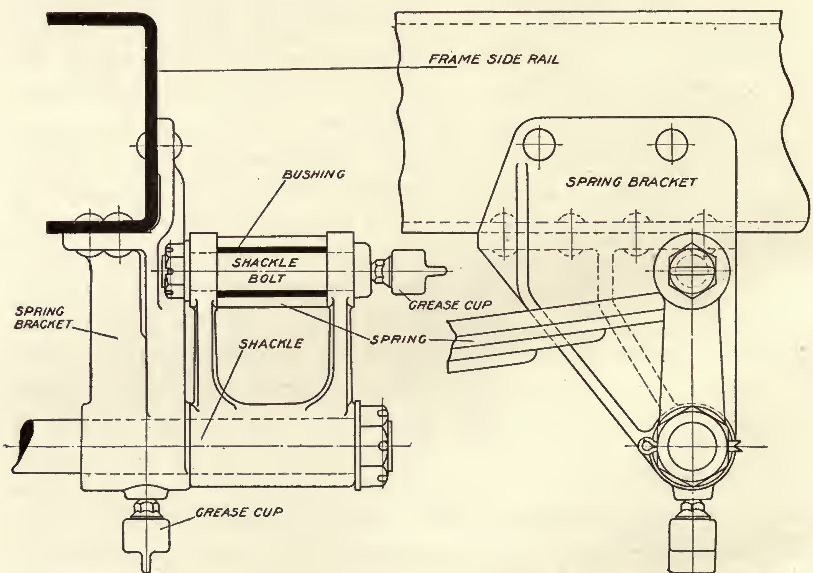


Fig. 222. Garford Rear Spring Shackled Construction.

Spring Alignment.—Although the clips at the center of the spring tend to hold the leaves in alignment, they alone are not sufficient, and in order to prevent lateral motion of the leaves some other provision must be made. One of the most common methods is to raise a central longitudinal rib on the main leaves for a certain distance as shown in Fig. 209. The rib of one leaf enters the corresponding gutter on the next. Another plan is to provide the leaves with lips at right angles as shown in Fig. 210.

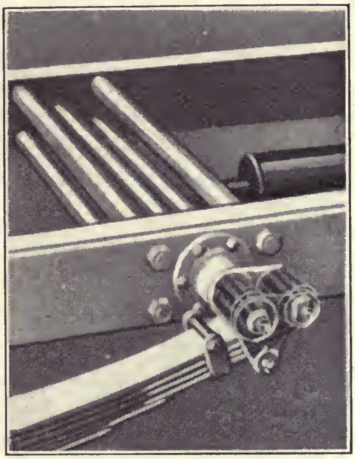


Fig. 223. Fulton Three Point Front Shackle.

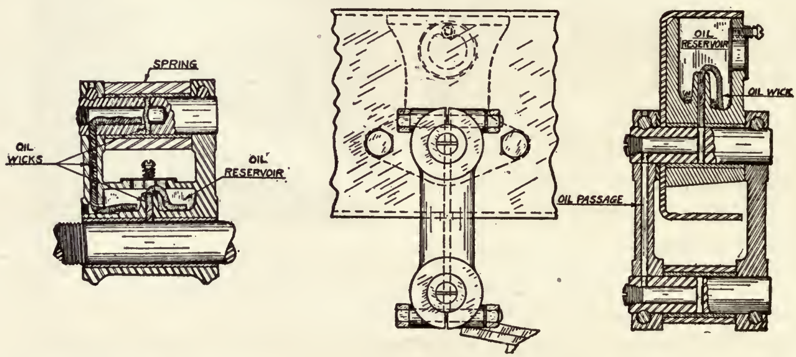
An objectionable feature of the center bolt is that it materially weakens the spring and quite often spring breakage can be traced to the weakness through the center bolt hole. For this reason the center band, which is shrunk over the leaves, is favored by a number of commercial car builders.

It is inadvisable to arrest abruptly the motion of a spring that is suddenly deflected, and for this reason bumpers or check springs, as they are sometimes termed, are used. Under exccessive deflection these bumpers strike the lower flange of the frame or brackets riveted to it for this purpose. The bumpers are so proportioned that they yield under the load, producing a cushion effect the same as rubber bumpers on pleasure vehicles.

Overload Springs.—Overload springs may either be of the leaf or coil type, and so arranged as to act only when the load on the main springs reaches a certain amount. Below this load they do not contact with their seat or wear plate. The wear plate may be a separate platform, as illustrated in Fig. 213, or it may be formed integral with the pressure block. When coil springs are used, they are made of square section, attached either to a frame cross member or the axle. Two such springs are used, one on each side.

Spring Clips.—The general desire to prevent breakage at the center is seen in the liberal proportion of the pressure blocks and spring clips. They represent the efforts of the various makers to provide a rigid connection between the spring and the seat. There is a growing tendency to employ the U-shaped spring clip which tends to exert an equal hold on each side of the spring, consequently the tension is equally distributed when the nuts are drawn up tight. They are made up of steel that will not easily become brittle under vibration.

Lubrication.—In most cases the spring eyes are bushed with phosphor-bronze or steel and shackle bolts are hardened and ground. The object of the bushing, of course, is to provide some means to renew the wearing surface. The bolts are working con-



Rear Spring and Shackle Assembly. Front Spring and Shackle Assembly.

FIG. 224. Wick Oiling System on the La France 2-Ton Truck Spring Shackles.

tinuously and will wear out quickly if they are allowed to remain dry. This lubrication is effected by grease cups which communicate with a hole in the bolt that permits the lubricant to reach the wearing surface.

In order to simplify maintenance some makers provide a wick oiling system for the spring shackles as illustrated in Fig. 224. This particular illustration depicts the La France construction, while the Fageol and Military class B vehicles are also provided with similar wick oiling systems. On the rear spring shackles oil reservoirs are cast integral with the shackles and wicks are inserted through drilled holes which feed the oil to the various bearings by capillary attraction. On the front springs the frame bracket carries the reservoir and a wick feeds oil to the upper pin which is hollow, thus permitting the oil to flow by gravity to the lower shackle pin or bolt.

Although friction between the spring leaves is desirable to an extent, yet it is necessary to keep the leaves lubricated when they bear against one another. This provision is usually made by the spring maker, and in most cases it is necessary to pry the leaves apart and introduce the lubricant with a knife.

CHAPTER XVIII

THE FUEL SUPPLY SYSTEM

The function of the fuel supply system of a commercial car is to furnish the carburetor with an unfailing supply of gasoline until the supply carried is entirely exhausted. This must be done independently of the grades encountered by the vehicle. The gasoline is generally fed by gravity from the tank to the carburetor, although one maker uses pressure feed, while several others use the vacuum system, which has been so successful on pleasure vehicles.

In the gravity system the "head" of fuel is depended upon to feed it to the carburetor. Tank location therefore is an important phase of this system, and requires the tank to be elevated above the carburetor. With this system the tank may either be placed on the dashboard or under the driver's seat. In a pressure feed system the tank may be located at any level with reference to the carburetor, since the fuel is always under a predetermined pressure sufficient to maintain a constant level in the carburetor float chamber. This pressure may either be obtained from the exhaust or by a special air pump.

In the vacuum system the suction of the engine is used to draw gasoline from the supply tank to an auxiliary tank, from which the gasoline flows by gravity to the carburetor.

Gasoline Tanks.—Gasoline tanks are generally made from tinned sheet steel, known as terne plate, and may either be pressed or formed to shape with ends and joints soldered or riveted and soldered. In order to provide the maximum mileage for a vehicle, they must be made to hold from twenty to thirty gallons and must be reinforced, so that the ends are protected from being forced out as the fuel rushes from one end to the other. These reinforcements or baffle plates also serve to prevent rattling due to vibration and sagging at the center of the tank. They are provided with holes or openings so that the gasoline can find a level in all compartments.

The filler cap and outlet are usually provided with strainers which are made from metal gauze, while shut-off cocks are provided in the outlet to shut off the supply. Some makers also provide a reserve supply in the tank. This is usually accomplished by a three-way cock fitted with a stand pipe which projects several inches above the bottom of the tank. Ordinarily the gasoline passes through this stand pipe, but when the lock

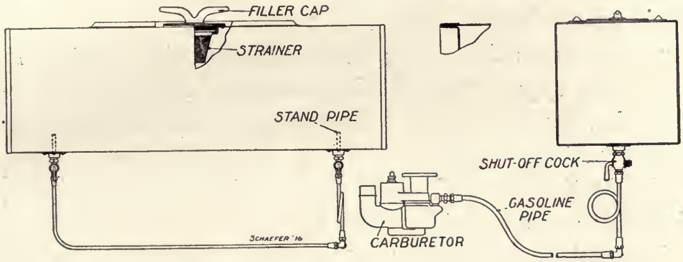


FIG. 225. Nash Quad Gasolene Tank and Gravity Feed System.

is turned to the reverse position, the fuel is permitted to pass through another opening flush with the bottom of the tank. These features are shown in the following illustrations.

Nash Quad.—Fig. 225 illustrates the Nash Quad gasoline tank and the feed pipe and carburetor. This also serves to illustrate the conventional gravity feed system. The filler cap is located

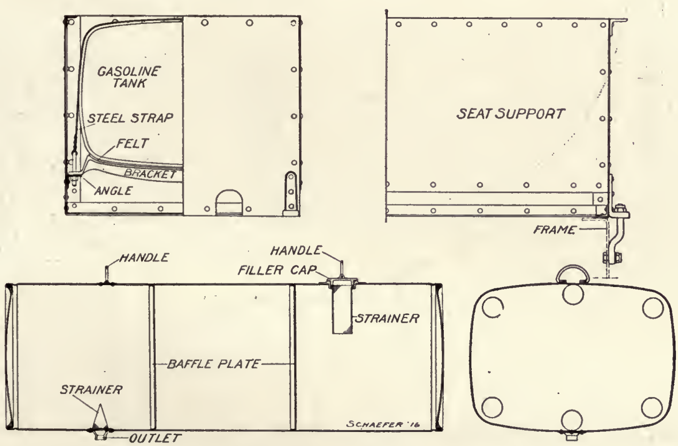


FIG. 226. Riker Gasolene Tank and Mounting.

near the center of the tank and is provided with a large handle so that it can easily be removed. A large strainer fits inside of the filler flange, which is riveted and soldered to the tank. The body of the tank is of rectangular shape and formed from a sheet of steel. The head is set in lapped and soldered as shown in the small sectional view. Two outlets with shut-off cocks are provided, so that gasoline may flow from either or both ends. Each of these cocks are provided with two openings level with the bottom of the tank for the reserve supply, while the regular supply is taken through the stand pipes.

Fig. 226 shows the Riker tank and mounting. This tank is of the bolster type, or modified rectangular shape and provided with two baffle plates for reinforcements. The heads are dished outward and the edges of the body are flanged over them and soldered. Both filler and outlet are provided with strainers, and two handles are soldered to the top of the tank so that it can easily be removed for repairs. The upper views show the method of mounting the tank in a steel compartment which supports the driver's seat. This compartment is made of sheet steel and a framework of small angles riveted together. Angles on the front and rear near the bottom support brackets which carry the tank. A strip of felt is placed between the brackets and the tank to form a cushion and steel straps hold the tank in position.

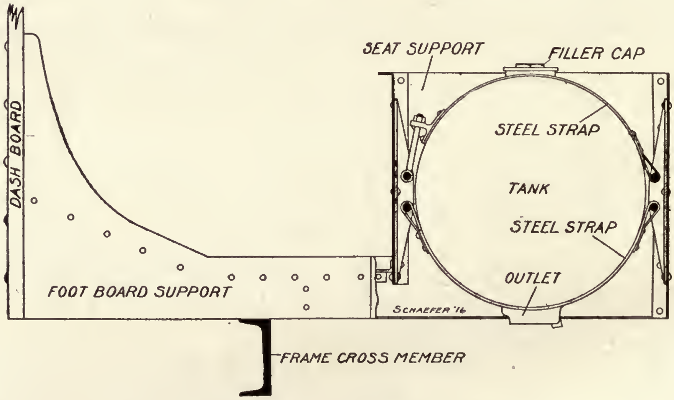


FIG. 227. Peerless Gasolene Tank Support.

Peerless and Pierce-Arrow.—Fig. 227 depicts the Peerless mounting. However, this differs from the above in that the tank, which is of cylindrical form, is supported and retained by steel straps. It is carried in a steel compartment supporting the driver's seat.

The Pierce tank is of rectangular shape and supported from the frame by means of sheet steel brackets and wood blocks as shown in Fig. 228. This mounting is so constructed that the framework which supports the seat surrounds the tank. A re-

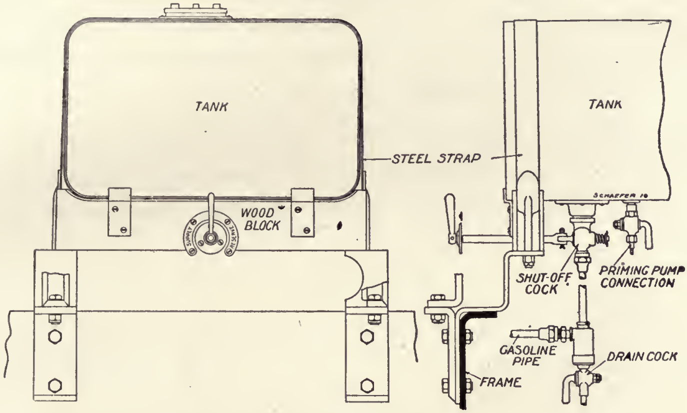


FIG. 228. Pierce-Arrow Gasolene Tank and Mounting.

serve compartment is provided and arranged, accessible through a handle outside of the seat compartment. Gasoline feed to the carburetor is by gravity and a connection is also made for priming the engine in cold weather. A hand-operated priming pump

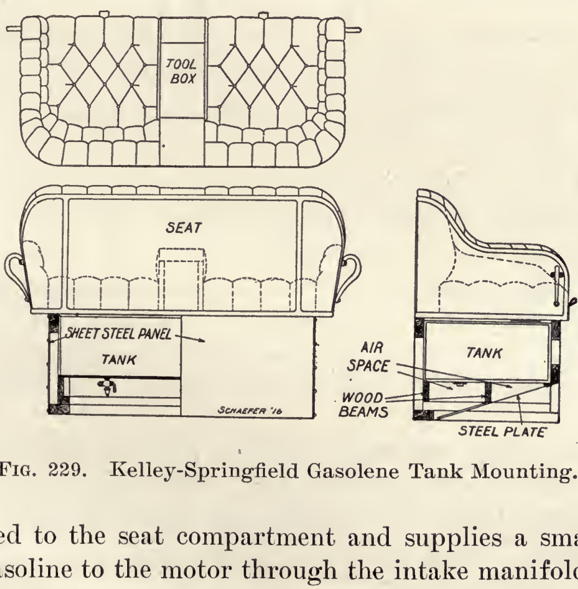


FIG. 229. Kelley-Springfield Gasolene Tank Mounting.

is attached to the seat compartment and supplies a small quantity of gasoline to the motor through the intake manifold.

On the Kelly trucks the seat compartment is also made of wood and the rectangular-shaped gasoline tank fits snugly in this. It is supported by wood beams at each end and at the center. The tank is placed well above the carburetor to provide the proper head as shown in Fig. 229. It is retained by wood strips and protected from excessive heat by a steel plate at the bottom, which provides an air space under the tanks.

Stewart and Autocar.—The Stewart tank (Fig. 230) is mounted in a wood seat frame. However, steel straps are attached to the tank and form brackets which rest on wood sills.

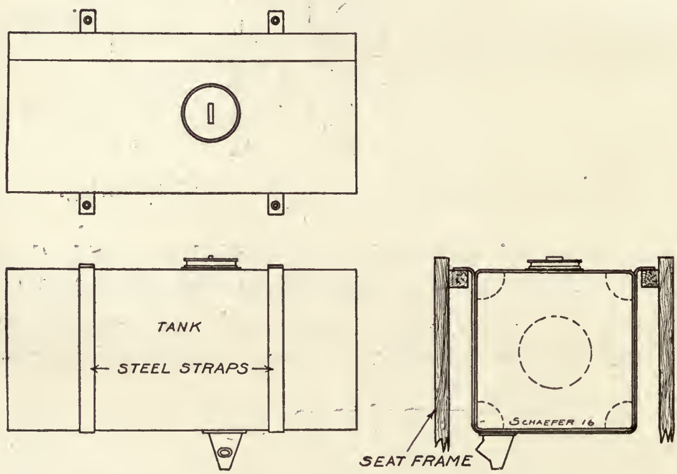


FIG. 230. Stewart Gasolene Tank and Mounting.

The Autocar tank (Fig. 231) is formed from a sheet but the ends do not lap, as a pressed cover is used. The heads are also pressed and set into the body. This construction permits riveting and soldering the head and all parts, while the cover which receives very little strain is soldered. This tank is mounted on steel brackets riveted to the frame and is retained by two rods which are supported by two brackets riveted and soldered to the tank.

Several makers use tanks which are drawn from one sheet of metal and have but one soldered joint. This type of tank is illustrated in Fig. 232, which illustrates the mounting of the United States trucks. These tanks are tinned inside and out and the head is soldered as shown.

The United States mounting consists of a separate frame or cradle, very rigid, having two brackets which rest on the vehicle frame, connected by a steel channel and a tie rod. Raybestos is riveted to the brackets to give a cushion effect, and the tank is retained by two steel straps. Gasoline feed is by gravity through

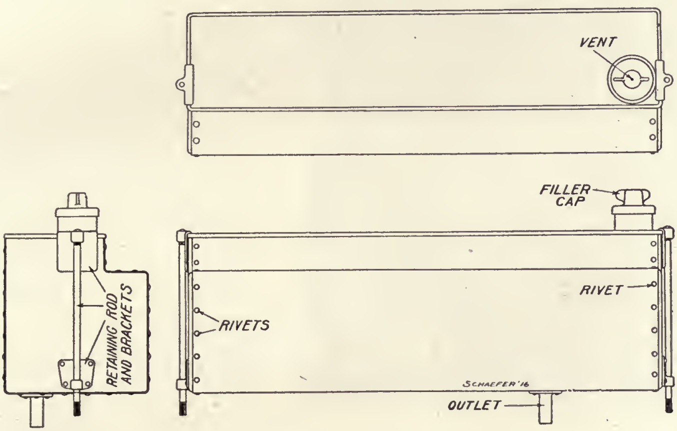


Fig. 231. Autocar Tank with Riveted and Soldered Ends.

a strainer attached to the tank and supported from the tank mounting.

Gasoline tanks when soldered and placed under the seat, have given some trouble due to leaks, as in some cases it is quite difficult to hold the tank in such a way as to prevent vibration from

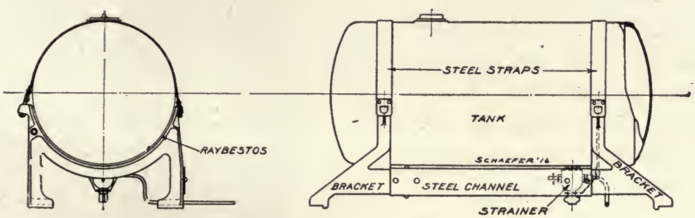


Fig. 232. U. S. Pressed Steel Tank and Mounting.

cracking the solder at the joints. The gasoline supply pipe also has its disadvantages since when the motor is placed under a hood, this pipe becomes quite long and it is difficult to keep it free from leaks.

In order to overcome these objections these tanks on the Denby and Union trucks are mounted on the dash, the Union mounting is illustrated in Fig. 233. This position provides the shortest gasoline line, reducing the danger of leaks due to vibration, while it also provides an ample head of fuel for gravity feed. This tank is supported by brackets and straps and is provided with a strainer and shut-off valve.

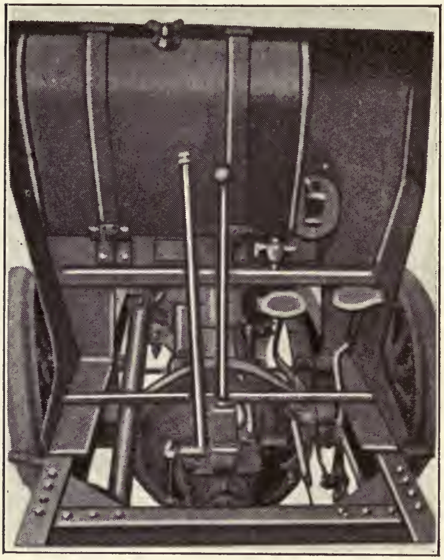


Fig. 233. Union Tank Mounting.

In the pressure feed system either the pressure of the exhaust gases or air pressure from a mechanical driven pump is used to force the gasoline to the carburetor float chamber. This system requires considerable piping, a pressure gage, a pressure regulator or pump and a hand pump.

Stewart Vacuum Feed.—The Stewart vacuum feed is used on the Knox tractor, Kissel Kar trucks and others and is shown in Fig. 234. The mechanism is contained in a cylindrical tank which may either be mounted on the engine or on the dashboard. The tank is divided into two chambers, the upper one being the filling chamber and lower the emptying chamber. The former contains a float valve and the connections to the intake manifold and the main fuel tank. The lower chamber has a connection leading to the carburetor. This lower chamber is always under atmospheric pressures as the flow of gasoline from it is by gravity

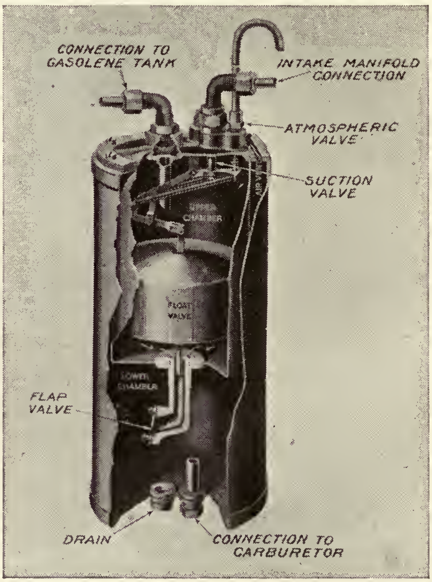


Fig. 234. Stewart Vacuum Tank.

only. Atmospheric pressure is maintained by an air vent which communicates with the chamber. The suction of the piston on the intake stroke creates a vacuum in the upper chamber, which closes a valve between the two chambers and in turn draws gasoline from the main tank. The gasoline, as it is being sucked into the upper chamber operates a float valve. When this float valve has risen to a certain mark, it automatically shuts off the suction valve and opens an air valve. This open air valve creates an atmospheric condition in the upper chamber and gasoline immediately commences to flow to the emptying chamber. When the float is at the bottom of its chamber, the suction valve is open and the air valve is closed. The lower chamber has a flap valve which prevents the gasoline in the lower chamber from being sucked into the upper chamber, as the float falls and opens the suction valve.

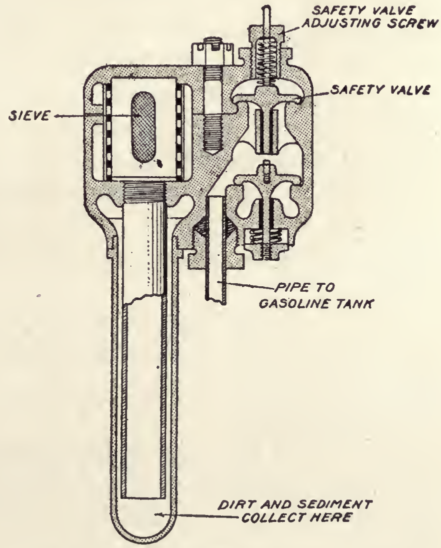


Fig. 235. Saurer Pressure Device.

On the Knox Tractor the gasoline tank is mounted on the running board and the engine suction through the system described above draws gasoline from the main tank and supplies the carburetor.

Saurer Gasoline Feed System.—The Saurer truck uses a pressure feed, the gasoline tank being located under the driver's seat and above the level of the carburetor when the tank is full. On the special Saurer carburetor, however, it was found that a constant pressure was essential to its proper functioning and the gasoline tank was moved from the rear of the truck to the driver's seat. Fig. 235 is a cross-section of the exhaust pressure device.

The exhaust gas enters and passes through a screen to remove carbon and fire, any small particles falling to the bottom of the long tube which can be removed for cleaning. The gas then passes to the other chamber through the valve which it lifts. The valve is returned to its seat by a spring to retain the pressure in this chamber and prevent its escape back into the exhaust manifold in the interval between exhausts. The upper valve is a sort of safety valve to prevent the pressure from becoming too great. This valve is regulated by the knurled screw on top of the device. The pressure is maintained at about two pounds.

Advantages and Disadvantages.—Each system has its advantages and its disadvantages. Gravity is an absolutely dependable and constant force which acts independently of an artificially created condition, and can be implicitly relied upon to cause the flow of fuel to the carburetor so long as the pipe is unobstructed and the upper surface of the fuel supply is at a higher level than the gasoline level in the carburetor float chamber. It is the most simple system on account of the simplicity of piping and fittings and there is practically nothing to keep in order.

The chief disadvantage is that the pressure under which the fuel is supplied to the carburetor is variable. Not only does it diminish progressively as the fuel level in the tank falls, on account of the reduction of the gravity head acting, but it also diminishes whenever that portion of the vehicle which carries the tank stands at a lower level than that which supports the carburetor.

With a forced system, as long as the artificial pressure is maintained, there is almost a certainty that gasoline will constantly be fed to the carburetor entirely independent of every other conditions.

The system possesses disadvantages in that there are numerous pipes and joints which must be kept tight in order that the tank may hold its pressure and the multiplicity of pipes and fittings adds to the possibility of leaks due to vibration.

The vacuum system is by far more simple than the forced system and eliminates the pressure pump, gages, regulator, a number of fittings and an air-tight tank. Leaks in pipes are materially reduced as the pressure is very low. Like the forced system it will supply gasoline to the carburetor regardless of grade, vehicle position or head of gasoline in the main tank.

This vacuum tank must not be installed in the exhaust side of the engine, as gasoline may leak or overflow from the tank and cause explosions or fires. Proper operation of the system depends entirely upon the float valve and if it develops a leak it cannot shut off the suction valve as it becomes too heavy to rise. Particles of dirt may also cause trouble by holding the flap valve open, which will render the system inoperative. The piping is also subject to the danger of vibration.

CHAPTER XIX

CONTROLS

The controls of a commercial car consist of the following: the spark, throttle, clutch, change gear lever, brakes and the steering gear.

The most important controls are the spark and throttle. The former may either be hand operated from the steering wheel, it may be so arranged as to cause ignition to occur at a predetermined point or it may be automatically controlled by the engine speed. The throttle may either be controlled by the driver or automatically. There are two means of manual control, by hand or foot. Automatic control was described in the chapter on governors.

The conventional type of control for cars with sliding gear transmissions, comprises two pedals located on opposite sides of the steering posts, the one at the left being the clutch pedal and the one at the right the brake pedal. The foot throttle or accelerator, if one is provided, is placed either between or to the right of these pedals for operation with the right foot. The mounting of these pedals depends upon the general construction of the vehicle. When a unit power plant is used they are generally mounted on the clutch housing; if the transmission is mounted amidships the common plan is to provide a tubular shaft extending partly or entirely across the frame, which is carried in brackets secured to the frame. Formerly the steering column was nearly always placed on the right side of the car, and the hand levers for operating the sliding gears and the emergency brake were located just outside of the driver's seat on the right. However, during the past years, quite a few makers have resorted to the left-side drive in which the steering column is located on the left side and the levers either on the left side or in the center.

On several makes of vehicles the clutch and service brake are operated by a single pedal. The first motion of the pedal releases the clutch and a continued motion applies to service brake. The emergency brake may also be operated by a pedal; however, it must be provided with a ratchet lock. The brakes and clutch may also be connected through suitable linkage so that when either brake is applied the clutch will also be disengaged. The idea which led to this construction undoubtedly was that if the driver wants to stop quickly he should simultaneously disengage the clutch and apply the brake, so that the driving effort ceases and no braking effort need be expended in dissipating the energy stored in the flywheel.

In order to prevent shifting of the gears while the clutch is engaged, some designers have provided an interlock between the gear sliding and clutch mechanism. This is generally so arranged that the gears cannot be shifted unless the clutch is out, and the clutch cannot engage unless the gears are in full mesh.

The advantages and disadvantages of the two control positions may be divided into general and mechanical. The advantages of one are, moreover, usually the disadvantages and advantages of the other, so the question may be discussed for one only. The two essential features of the left side control are: first, greater ease in getting out of the vehicle on the right side, and second, the bringing of drivers meeting vehicles next to each other, lessening the dangers of collision.

The first is of importance only as regards convenience of both operator and helper. The second point is well worthy of consideration, as when two vehicles meet on narrow streets or roads, the distance between the two must be judged with great nicety in order to prevent scraping mud guards or bodies and locking wheels. The disadvantages are the difficutly of judging the distance from the curb, the distance of an overtaken vehicle and in some cases the difficulty in mounting the control levers.

The first claim seems to be a difference of opinion, as there are some who claim one is no more difficult than the other. However, if the distance is not judged properly the tires will suffer, not mentioning the strain imposed on the wheels, axles and steering knuckles in striking curbs.

In overtaking vehicles the driver is on the left side, and farthest from the overtaken vehicle, and this would seem to be offset by the advantage of bringing the operators of meeting vehicles next to each other, but a close study seems to point in favor of the right side control, for in the case of meeting vehicles two operators are watching and able to judge distance, while in overtaking vehicles there is only one who can judge the distance.

The mechanical points relate to details of design and apply to each type; however, the center control offers an advantage in that the gear lever can be mounted directly on the transmission, thus doing away with superfluous connections.

Spark and Throttle Controls.—Various types of these controls were illustraed in Chapter XIV, describing the steering gear. The general practice is to incorporate these in the steering gear, while the foot throttle or accelerator consists of a small pedal mounted on the dash or foot board and connected with the hand throttle in such manner that it can be operated without changing the position of the throttle lever on the wheel. This is accomplished by a slip joint, as shown in Fig. 236. The accelerator is hinged to the steering column and connected to the carburetor throttle lever by a rod which carries a slip joint. This joint has an extension to which the hand throttle is connected. The accelerator is normally held in the off position by a coiled spring.

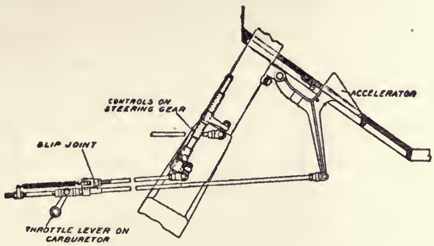


FIG. 236. Pierce Throttle Control.

Another type of accelerator was illustrated in Fig. 176, Chapter XIV, showing the Reo steering gear.

The advantage of the foot throttle is that it permits the operator to control the speed of the engine with his right foot, thus leaving his right hand free to change gears, and the left to steer the vehicle. The advantage of quick gear-shifting is not to be denied, as anything which tends to reduce engine racing, gear clashing, etc., is quite desirable. However, motor trucks operate on solid tires and the floor boards are constantly vibrating, and all of the minor shocks which the vehicle springs do not absorb are transmitted to the cab. This vibration makes it quite difficult for the operator to keep his foot steady, as the slightest movement of his foot acts directly upon the throttle. Sudden acceleration is another disadvantage which is to be avoided. The hand throttle of course eliminates this, and it is possible to hold it stationary on the quadrant. Disadvantages of the hand throttle, besides the inconvenience in changing gears, includes the danger of shifting gears without throttling down the engine.

Brake, Clutch and Gear-shift Controls.—There are two general types of pedals, the straight and the bent type, both of which are illustrated. These pedals have to pass through the floor boards and their shape is dependent upon the room available. They may either be drop forgings or steel castings, and vary from 10 to 16 inches in length, depending upon the required leverage.

Brake and change-gear levers are generally drop forged of I-beam section, and in most cases pivot from a common pivot axis. The change-gear lever of selective type change gears moves in an H segment or gate and does not require a latch to hold it in position. However, a lock is sometimes provided to obviate the possibility of accidentally engaging the reverse gear. A latch lever must always be used with a progressive gear control, and the emergency brake lever must also be provided with a latch. There are two general types of selective gear controls which are termed the sliding shaft and swinging lever types. While all controls may be classified under these two heads, there are numerous variations in detail.

Sliding Shaft Control Set.—The Pierce five-ton control set (Fig. 237) is of this type and mounted on the right side rail of

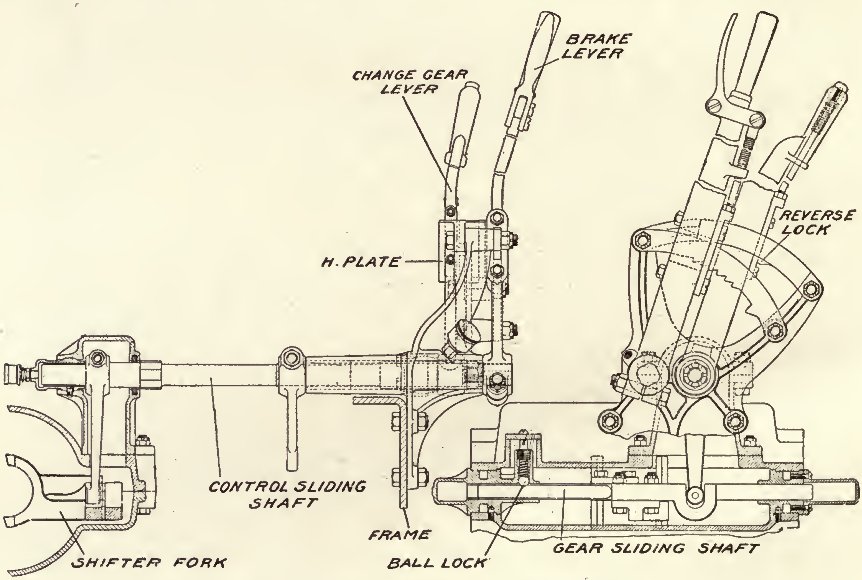


Fig. 237. Pierce Selective Type Control.

the frame, as the controls are arranged for right side drive. This selective gear control comprises a sliding shaft to one end of which the control lever is rigidly secured, and which at its inner end carries a downwardly extending arm which is arranged to engage with a semi-circular slot in one or the other of the sliding shafts of the transmission which carry shifting forks. The sliding shafts are provided with ball locks, which help to find the correct mesh, and also prevent shifting of both shafts together. The H plate or quadrant, which guides the lever in shifting to the various speeds, is placed slightly forward of the emergency brake lever and has a lock controlled by thumb latch on the lever

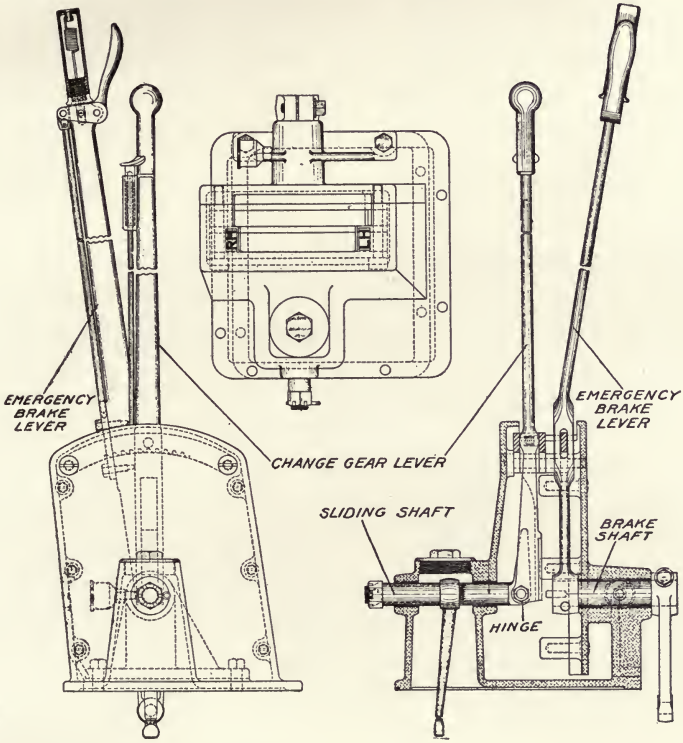


Fig. 238. Brown-Lipe Center Control Unit for Unit Power Plant Transmissions.

handle for locking out the reverse gears. The gear shifting mechanism also has a lock which prevents shifting gears until the clutch has been disengaged. This consists of a semi-circular cam or segment keyed to the sliding shaft of the control set and a plunger connected with the clutch pedal, which, while the clutch is engaged rests in holes in the cam surface. To shift gears the clutch must first be disengaged which also disengages the plunger.

The emergency lever is of the spoon latch type which releases a lock fitting into the ratchet teeth of the brake quadrant.

Another type of sliding shaft control is shown in Fig. 238. This is furnished by the Brown Lipe Co. with their transmissions for left side control, and is used on a number of commercial cars. This differs from the one above in that the control lever is hinged to the sliding shaft, and pivots in a rectangular shaped quadrant. Instead of the lever sliding with the shaft, it pivots to either side in the quadrant and moves the shaft in the opposite direction to which the lever is moved. The emergency brake lever has a spoon latch which operates on the conventional ratchet quadrant, and is pivoted from the same center as the gear lever, but its shaft extends to opposite side of the housing, which encloses the entire control. This type of control is intended for unit power plants where the transmission usually is located under the foot boards.

The Swinging-lever Type.—A swinging-lever type of control used on several cars is shown in Fig. 239, and is designed for right-side control and frame mounting. The change gear lever

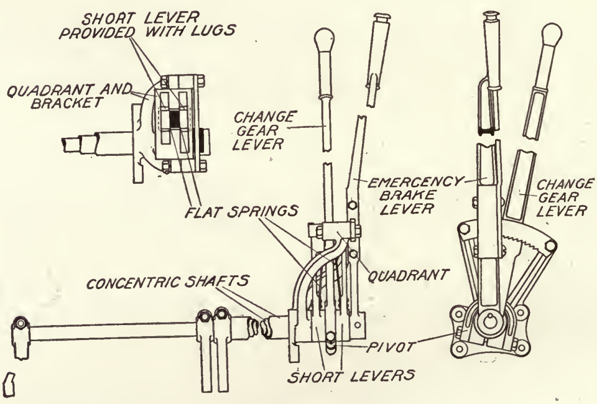


Fig. 239. Swinging Lever Type of Control.

is pivoted to a hub which is free to turn on the control shafts. On each side of this lever are short levers which are fastened to concentric control shafts, each of which extend to the inside of the frame and carry operating arms. These arms are connected to the sliding shafts of the transmission by rods and clevises. The upwardly extending levers are provided with lugs, between which the control lever engages when it is pressed in the direction of the particular short lever. Some provision must be made for holding the change-gear lever in a natural position, and this is accomplished by the two flat springs fastened to the short levers. When the control lever is moved in one of the slots of the quadrant it is connected with one of the short levers and turns the shaft to which that lever is secured.

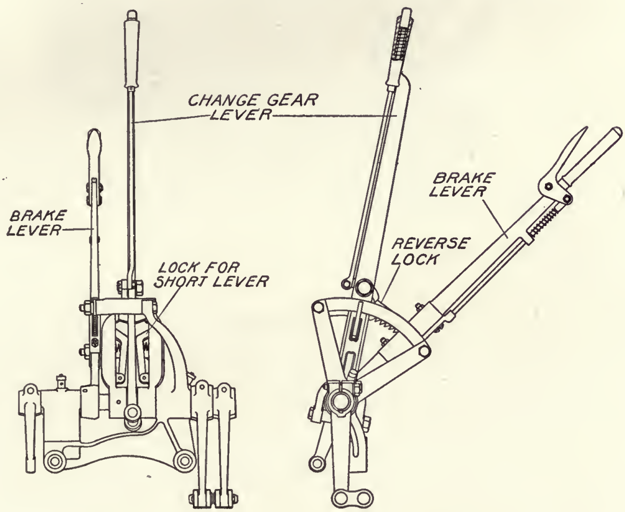


Fig. 240. Warner Swinging Lever Arranged for Center Control with Right Hand Drive.

Fig. 240 illustrates another type of swinging lever control which was introduced by the Warner Gear Co. for unit power plant mounting. It differs from the above in the method of engaging the control lever with the short levers that turn the concentric shafts. These have small arms hinged to them, which are held in contact with the control lever by spiral springs. The pivoted arms have a lug which engages in a slot in the quadrant and locks each shaft in position. This type of control eliminates the danger of turning both shafts at the same time. It also incorporates a reverse lock controlled by a thumb latch on the control lever.

Center control may also be employed with the transmission located amidships or on the jackshaft. An excellent example of this is shown in the United States control, Fig. 241, in which the support for the gasoline tank is used to support the control.

FIG. 241. United States Center Control Mounting.

Center Control and Pedal Mounting.—On the Flint delivery cars the center control and pedal mounting is incorporated in a single unit supported from the subframe as shown in Fig. 242. The control set is of the swinging lever type; however, instead of using a quadrant and concentric shafts, the short arms are connected with two parallel shafts which are provided with plunger locks. The short levers instead of pivoting from the center of the control lever, slide with the shaft. This construction permits placing the sliding shafts in the transmission directly above the gears, making a direct connection and eliminates the trouble usually experienced with bent connections.

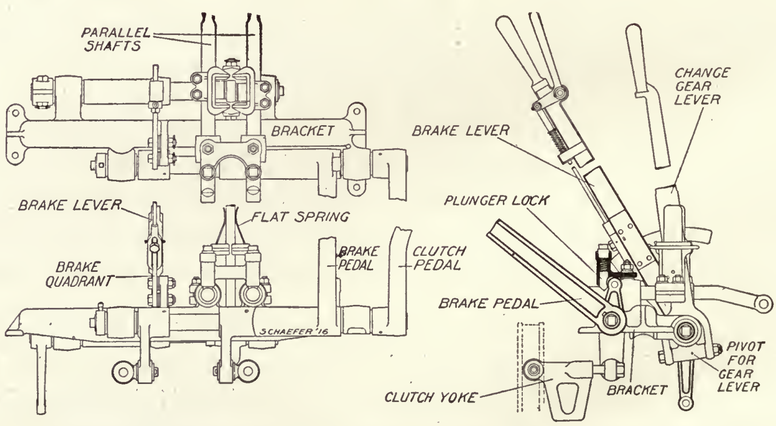


FIG. 242. Center Control and Pedal Mounting of Flint Delivery Cars.

A large bracket extends from one subframe member to the other and has bearings at its rear end to support the control and brake lever, while bearings are provided at the front end of the pedals and their shafts. The service brake connection is made from a small lever cast integral with the brake pedal, while the clutch is connected to the pedal through a yoke and levers, keyed to the shaft. The brake pedal is interconnected with the clutch pedal so that in applying the brake the clutch will also be disengaged.

Fig. 80 depicts a unit power plant transmission with the center control and pedal mountings for left-side drive. The swinging control lever instead of being pivoted at its lower end, has the pivot, which is of spherical shape, a short distance from its end and rests on a bracket incorporated with the transmission cover. The end of the lever engages with the shifter forks in the transmission which have lugs that straddle the lever. This makes a very simple control and eliminates a number of parts. The emergency brake lever is mounted at the side of the transmission and is also pivoted a short distance from the end. The lower end has a connection for the brake rod and a slot through which the quadrant is inserted. The pedals are mounted on an extension of the clutch disengaging shaft. Both of these are free on the shaft, but the clutch pedal is connected to a sector which permits pedal adjustment to take up the wear of the clutch.

Progressive Type Control.—In the progressive type of transmission it is necessary to progress from one speed to another and for this reason it is necessary to provide a control which has a lock for each speed and the neutral position. The Mogul heavy duty trucks are equipped with a progressive type transmission which is built in a unit with the jackshaft, while the operator's seat is placed over the engine. This makes it difficult to arrange a neat control; however, in the Mogul trucks the control levers and pedals are supported from a single bracket. Both gear and brake levers pivot from the same center and are mounted upon concentric shafts. Since a lock is required for both levers, these are equipped with spoon type latches. The pedals also pivot from a center common to both, but this is somewhat below the center of the levers as shown in Fig. 243.

The position of the control levers also makes it difficult to obtain a direct connection to the sliding shaft in the transmission. In this case it is quite simple as an extra long lever is pivoted from the seat support which connects with the control lever near its pivot end, while the other end is connected to the sliding shaft.

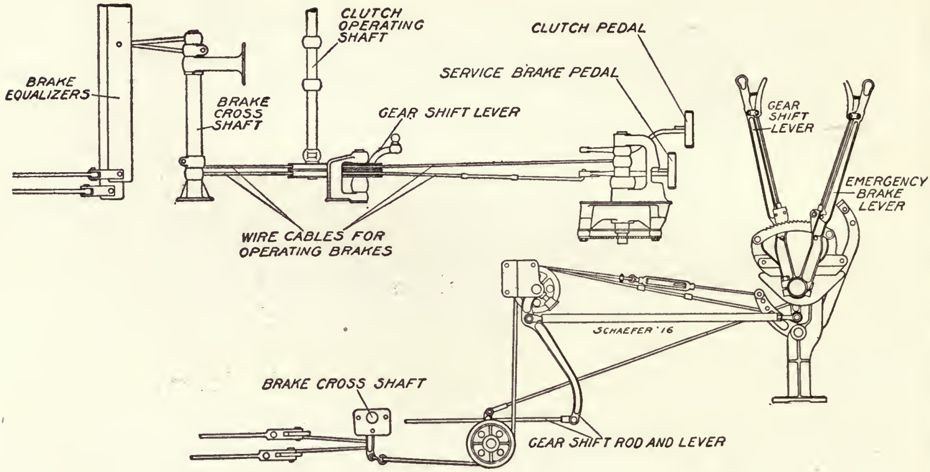


Fig. 243. Mogul Brake, Clutch and Progressive Type Gear Control.

Brake Linkage.—Unless the breaking force applied to the rear wheels is equalized, that is, that brakes on opposite sides produce equal retarding forces, the car has a tendency to skid and brake adjustment is also quite difficult. This necessitates an equalizing device in the brake operating linkage, which will apply an equal retarding effect to the two brakes of each set. This equalizer is dependent upon the general scheme of the linkage and in most cases is of the whiffletree or modified whiffletree type. The brake linkage is dependent upon the general layout of the chassis.

With the seat mounted over the engine, it is necessary to arrange this so it will provide maximum accessibility for the engine, and Fig. 243 illustrates how this is accomplished with wire cables on the Mogul trucks. Short rods are connected with the brake pedal and lever and carry turnbuckles which are attached to wire cables. These cables pass over pulleys mounted on the seat frame and the clutch disengaging shaft. They connect with a cross shaft, which in turn is connected with equalizers of the whiffletree type. From these equalizers, rods and clevises form the connections to the brake. The clutch connection is made with a rod direct from the pedal to the clutch disengaging shaft which is supported from the subframe.

On the Natco trucks (Fig. 244) the engine is mounted under a hood and the linkage consists of rods throughout.

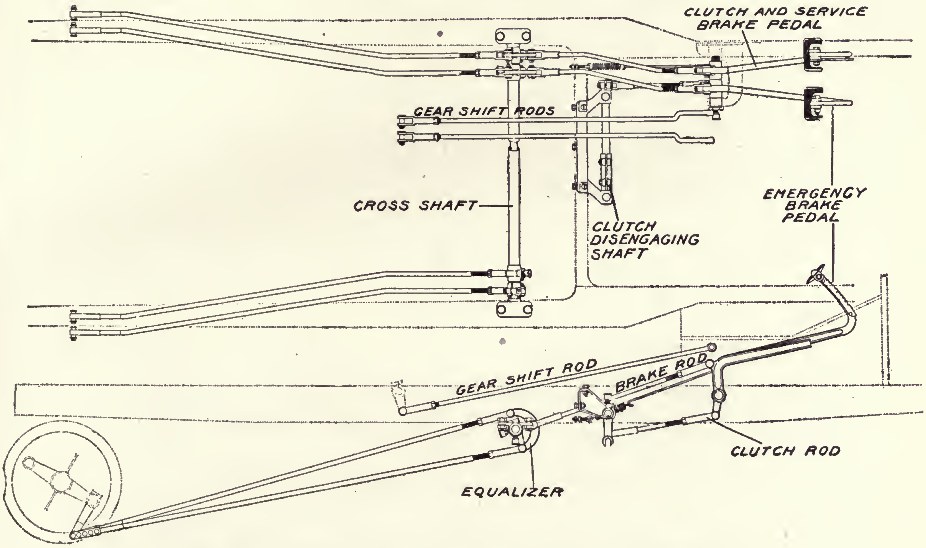


FIG. 244. Natco Brake Rod and Pedal Arrangement.

The pedals are supported by a bracket attached to the frame, while a cross shaft is arranged to incorporate an equalizer for each set of brakes. The clutch pedal also operates the service brake, while the brake pedal has a ratchet which locks auto-

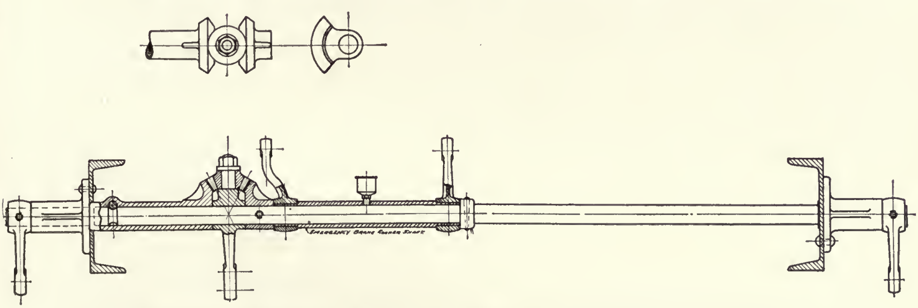


FIG. 245. Peculiar Brake-Rod Equalizer of the U. S. Truck.

matically and is released by tipping the pedal pad. The brake equalizer is of a modified whiffletree type and is mounted vertical instead of horizontal.

An equalizer which is a modification of the bevel gear differential, is used on the United States trucks and shown in Fig.

245, in which the ordinary brake levers which usually form connections for the modified form of whiffletree equalizer are replaced by bevel gear sectors. The lever to which the brake rod is connected has a spindle upon which a bevel pinion is mounted which meshes with the bevel sectors on opposite sides. This pinion is free to rotate upon its spindle and as the brakes are applied it equalizes the pull on the brake rods on opposite sides of the frame in the same way as the differential equalizes the power applied to the rear wheels.

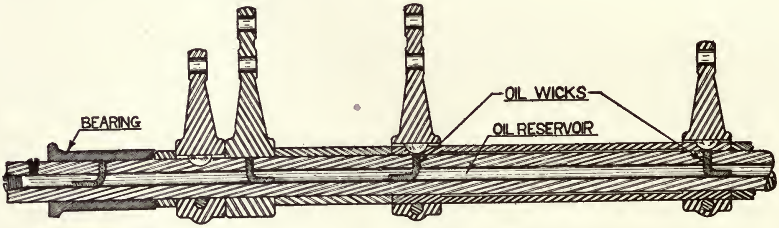


FIG. 246. Wick Oiling System on the La France 2-Ton Truck Brake Shafts.

Most brake shafts and their bearings are lubricated grease cups; however, on the La France trucks the brake shaft assembly (Fig. 246) is lubricated by oil. Both shafts are hollow and the inner one forms the oil reservoir, which will carry sufficient oil to lubrciate the brake levers for a long time. Wicks are led from the central oil reservoir to the various bearings. The oil is put into the reservoir conveniently from the outside of the chassis at the end of the transverse shaft.

CHAPTER XX

THE MUFFLER

Although it is not essential that motor trucks operate as quietly as pleasure cars, it is quite essential that they operate without disagreeable noise. For this reason the exhaust must be muffled, which is accomplished by passing the spent gases through a muffler before they are discharged into the atmosphere. This muffler is sometimes referred to as a silencer. The object of the muffler is to permit the gases to expand and to cool, thereby reducing the pressure, which is the cause of the noise when they are discharged into the atmosphere directly. It is quite simple to obstruct the passages of the gases from the engine to atmosphere, however, in order to discharge them without disagreeable noise, they must be permitted to escape very freely, so that they will not create any back pressure on the pistons during the exhaust stroke.

Muffler not Close to Engine.—In most cases the muffler is mounted as far away from the engine as the general chassis design permits. It is usually mounted under the frame of the vehicle. This arrangement permits the engine to exhaust into an exhaust pipe of considerable length, the capacity of which is sometimes as much as four times the piston displacement of one cylinder. This long pipe gives the gases a chance to cool before they reach the muffler, while the latter should be arranged in such a manner that heat may rapidly be abstracted from the gases.

Mufflers generally consist of a series of expansion chambers which communicate by means of fine and sometimes tortuous passages, and after passing through these chambers the gases are finally permitted to escape. Mufflers should possess certain features, a construction which permits cleaning, strength to withstand pressures of gasoline—air vapor explosions at atmospheric pressure and ability to resist vibration. Cleaning is necessary, as lubricating oil and solid carbon particles held in suspension by the gases will clog the fine passages and increase the back pressure. Some mufflers are so constructed that they can be dismantled for cleaning. Explosions in the muffler are frequent, and it is essential to have enough strength to resist this pressure without bursting. The walls of the muffler may be so designed as to prevent ringing which is really a harmonious vibration of succeeding exhausts. This is sometimes accomplished by lining the outer shell with sheet asbestos, but this may not seem very desirable, as it possesses certain heat insulating qualities.

The final outlet is generally through a pipe of considerably less cross section than the exhaust pipe. This is sometimes flattened so that the gases escape in a continuous sheet. In some cases this is accomplished by a series of small holes in the final outlet or the outer shell.

Cut-outs.—In order to relieve the so-called back pressure of the muffler, cut-outs are sometimes provided, which are placed forward of the muffler or in the exhaust pipe, and permit exhausting the gases directly into the atmosphere, instead of having them pass through the muffler. The general claim for this cut-out is that it adds to the efficiency and power of the engine. However, it has been proven that with a well designed muffler a cut-out is of little value, except that the operator may occasionally listen to the action of the engine.

Pierce Muffler.—The Pierce muffler (Fig. 247) consists of two adjacent cylindrical chambers, which communicate through a number of holes in the inner chamber. The outer chamber is divided into three expansion chambers, while the inner member

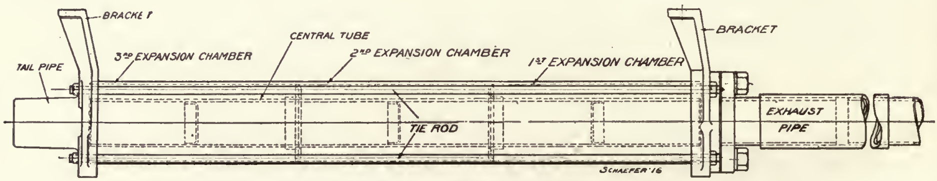


FIG. 247. The Pierce Muffler.

is also divided into three parts, the partitions of each member being pressed steel discs. The gases first enter the inner chamber and pass through perforations into the outer chamber and from this chamber they return to the second portion of the inner chamber and thence into the second expansion chamber, thence through the central member into the third expansion chamber and back into the central member from which they are discharged. This muffler is mounted parallel to the side members of the frame and has cast end plates which have integral brackets for frame mounting. The tubular members and end plates are held together by long tie rods which extend the full length of the muffler.

Packard Muffler.—The Packard muffler (Fig. 248) also consists of an inner and outer chamber with cast end plates, retained

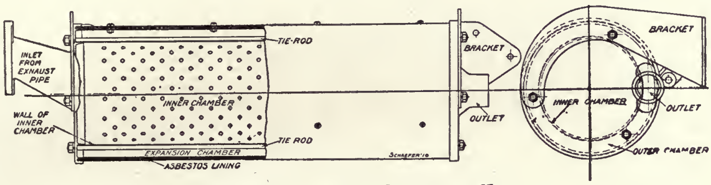


Fig. 248. The Packard Muffler.

by tie rods. However, the necessary volume is obtained by increasing the diameter instead of making the muffler of considerable length. The inner chamber has a series of small holes, through which the gases pass after expanding in the inner chamber. After expanding in the outer chamber they escape at the rear end. This outer chamber is insulated with sheet asbestos retained by plates and small screws to deaden the vibration. The supporting brackets are made of pressed steel and fit into the side members of the frame.

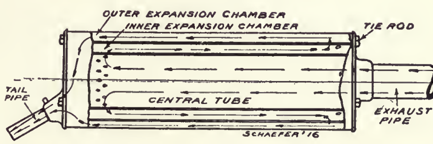


Fig. 249. The Gray-Hawley Muffler.

Gray-Hawley Muffler.—The Gray-Hawley muffler (Fig. 249) is used on a number of commercial cars and consists of two cast heads which support three cylindrical sheet metal tubes. The gases enter the inner one of the three members from the exhaust pipe. They expand in this chamber and then pass through fine perforations at the opposite end in the partition wall into the intermediate chamber, and thence through similar perforations at the rear end of the innermost portion wall into the outer chamber from which they escape at the further end. The path of the gases is shown by the arrow-heads in this illustration.

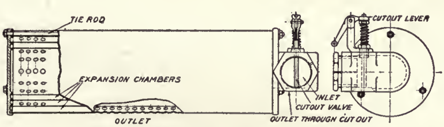


Fig. 250. The U. S. Muffler with Cutout.

United States Muffler.—The United States trucks are equipped with the muffler shown in Fig. 250 which is similar to the one previously mentioned. The gases take the same path and are expanded in a similar manner. However, they are discharged through perforations at the center of the outer chamber, as this muffler is mounted crosswise at the rear end of the subframe. Into the head, which connects with the exhaust pipe, a cut-out is placed. This cut-out consists of a poppet valve, held to its seat by a spring and bell crank pivoting in a bracket operated through suitable linkage from the operator's seat. When this cut-out is opened by raising the valve from its seat, the greater part of the gases take the path of the least resistance, which is through the valve opening instead of passing through the various expansion chambers.

Riker Muffler.—The Riker muffler (Fig. 251) is somewhat similar to those depicted above, except that the inner chamber is perforated at both ends and the outlet is of a different shape. Both end plates or heads are provided with flat surfaces to which the supporting brackets are bolted. The front head has an opening against which a flat valve is held through the pressure exerted by a coiled spring attached to the end of a bell crank and the head. The bell crank supports the valve, which is raised from its seat when the cut-out pedal is depressed. Both exhaust and outlet pipes are attached to the muffler heads by flanges and bolts.

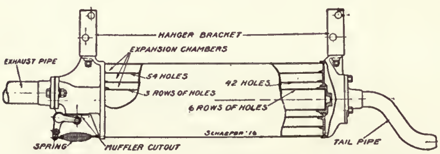


FIG. 251. Riker Muffler and Cutout.

Powell Muffler.—The Powell muffler is also used by some makers of commercial vehicles. This consists of a number of pressed steel cups, the open ends of which are flanged out so as to fit over the closed end of the adjacent section or cup. Each of the cups *A* are perforated and through these perforations the adjacent chambers communicate. Cups *B* and *C* are used at the rear end and are so arranged as to form a somewhat tortuous passage for the gases. This is accomplished by a series of small

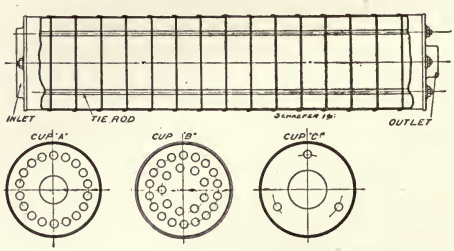


FIG. 252. The Powell Muffler.

perforations in cup *B* while cup *C* has a large central hole. Three tie rods hold the various sections together, which permits using any number of cups to meet the requirements of each individual engine to which the muffler may be fitted. Fig. 252 shows this muffler as applied to the Mogul trucks, and Fig. 253 illustrates its application to the Knox tractor, in which it is mounted crosswise at the front end of the frame.

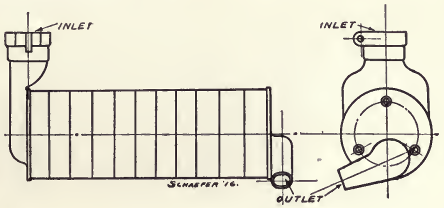


Fig. 253. The Knox Tractor Muffler.

Denby Muffler.—A pressed steel muffler has recently been introduced by Gueder, Paeschke & Frey Co., which is used on the Denby trucks. This is illustrated in Fig. 254, and consists of a number of pressed steel cups placed in a steel shell and electrically welded. This makes a very light construction and the claim is made that it weighs but five pounds. The gases enter at

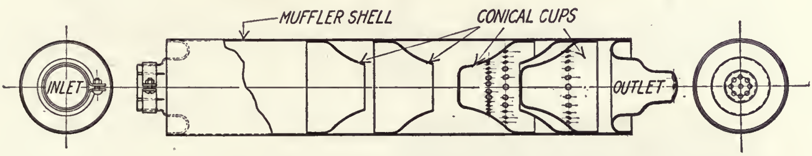


Fig. 254. The G. P. & F. Muffler.

the forward end and pass through conical-shaped cups which are so spaced that an expansion chamber is formed between them. The remaining cups are of similar shape, but reversed in position and also provide limited expansion chambers between them. The first of these is perforated, while the second has but one large central hole, and the third has but half the number of perforations of the first one. The outlet, instead of having one large central opening, is also perforated, so that the gases escape in continuous streams.

Fig. 255 depicts another popular type of muffler known as the "Dunco," which operates on a principle of automatic adjustment which is that of the well-known steam ejector. A portion of the exhaust gases pass directly through a central tube to a high speed jet, at the outlet of that tube, and induce a partial vacuum behind them, thus drawing the remaining gases through baffle plates or cones in the muffler. It is claimed that this muffler is self-adjusting to variations in speed, and the frequency of injector impulses varies directly as the speed of the engine, so that the pull of the ejector is always proportional to the volume of

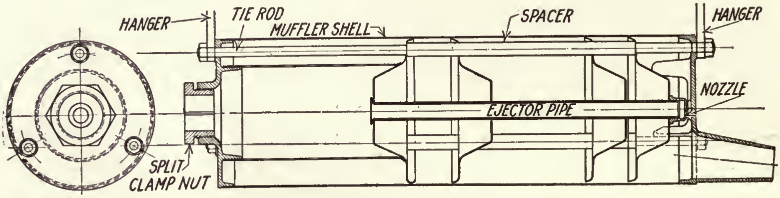


FIG. 255. Dunco Ejector Type Muffler.

gas to be drawn through and discharged. The heads are malleable castings and tie rods hold the entire construction together, so that it is very simple to take the muffler apart for cleaning.

Maxim Silencer.—The Maxim silencer (Fig. 256) incorporates a somewhat different principle in which but one tubular member is used. The interior construction is of a peculiar built spiral chamber, which, it is claimed, can not clog or collect carbon. The gases enter at one end and pass from inlet to outlet without obstructions of any kind. This continuous channel has the peculiarity of circular or helical form, and, owing to the centrifugal force of the fast moving gases, these gases whirl to the outer periphery, traveling an approximate distance of three and one-half times the length of the muffler. Slow moving gases will remain at the center and gradually move forward to the outlet. The heads are malleable, while the shell is made of sheet steel, seamed and electrically welded to prevent bursting.

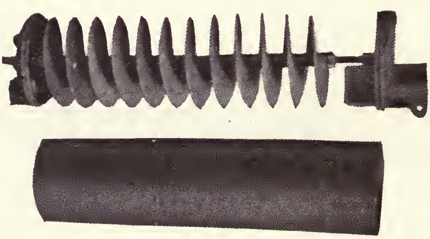


FIG. 256. The Maxim Silencer.

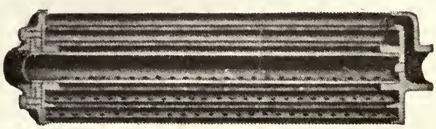


FIG. 257. The Old Berg Muffler.

Oldberg Muffler.—The Oldberg muffler (Fig. 257) has a series of expansion chambers. The gases enter the center member and, due to the arrangement of the perforations, immediately start to pass out and around to the opposite side. Each alternate tube is placed eccentrically with respect to the axis of the muffler. The perforations in each tubular member are arranged in two rows throughout their length. The total area of these perforations is greatly in excess of the area of the exhaust pipe connecting with the muffler. The sound waves are interrupted by passing half of the gases around each side of the tubular members, the two streams coming together on the opposite side of the preceding chamber.

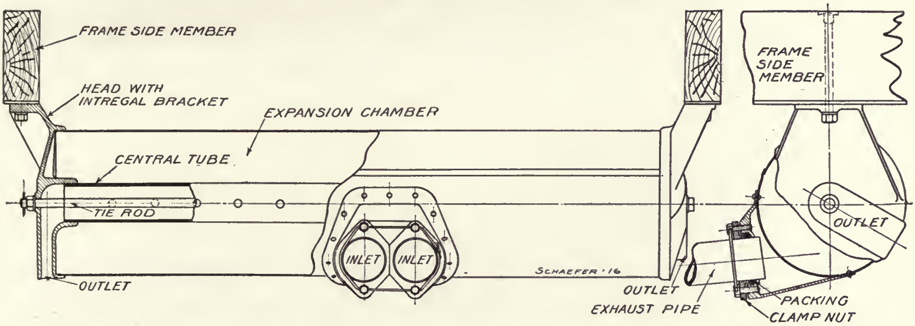


FIG. 258. The I. H. C. Muffler for Two-Cylinder Opposed Motor.

The mufflers described above apply to four and six cylinder engines, while Fig. 258 illustrates the I.H.C. construction for their two-cylinder engines. It consists of an inner and outer shell with cast heads retained by a single tie rod. The gases enter the outer chamber near its center through exhaust pipes from each cylinder. They expand in this outer chamber and pass through perforations in the walls of the inner member, whence they escape at both ends, as the muffler is mounted crosswise at the rear end of the frame. The outlets and mounting brackets are cast integral with the muffler heads. The end view illustrates the method of retaining the exhaust pipes with packing joints.

The exhaust system begins with the exhaust manifold of the engine and includes the exhaust pipe, cut-out and muffler. Practice differs with the various makers however. What has been outlined in this and previous chapters on the engine serves to give a general idea of the subject.

CHAPTER XXI

MOTOR TRUCK WHEELS

Road shocks must first be taken by the road wheels, through tire contact, and thence distributed, spreading out in all directions from the hubs of the wheels.

There are essentially three types of wheels used on motor trucks at present: wood wheels of the artillery type which are used on a great number of machines, pressed steel and cast steel wheels.

Artillery Wood Wheels.—The artillery type of wheel consists of a set of spokes turned from very tough wood, generally second growth hickory, which are clamped at their inner end between flanges on a metal hub and at their outer end tenoned into a wooden felloe, which is surrounded by a steel band or ring. The spokes may be either of elliptic, square or rectangular section, and great care is taken to get the fiber to run exactly in the direction of the spoke length. It is common practice to split the spoke billets instead of sawing them.

The wood used in the spokes and felloes is made from well-seasoned timber, so that strength and toughness in the highest degree can be obtained. Second growth stock and stock from the lower portion of small trees yields the best parts.

In truck work when solid tires are used the spokes are of square or rectangular section, since these are stronger in proportion to weight than the elliptic spoke.

The greatest amount of trouble with the artillery wheel has been experienced with those used on very heavy trucks. The spokes are very thick and a comparatively slight shrinkage of the spoke causes them to loosen in their hub and the severe jarring, due to the use of solid tires, then has a very destructive action. In order to deviate this difficulty and strengthen the spokes assembly at the center the Schwartz Wheel Co. make the miter of the spokes interlocking, while other makers provide keys between the miters or adjacent spokes.

Steel Wheels.—Cast-steel wheels are now gradually coming into use, while pressed steel wheels are also used on some of the vehicles having less than two tons capacity. The steel wheel is very popular in foreign countries, and American manufacturers are gradually using them. In some cases they have not succeeded, while in others they have given excellent service, which is also true of the wood wheel.

The advantages possessed by the steel wheel for heavy duty are strength, true shape, rigidity, concentricity of the hub and accurate design for the support of the load. In point of strength and elastic limit, the steel wheel well made, is superior to the

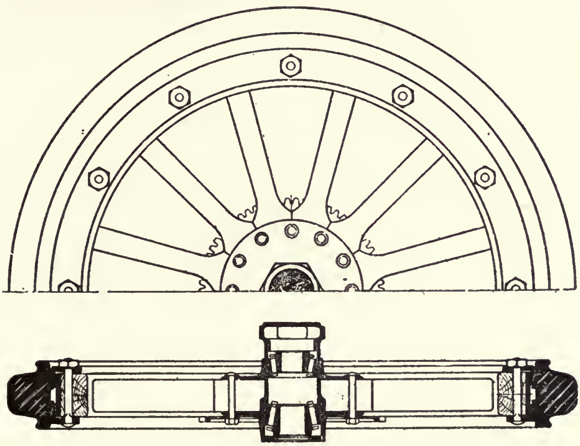


FIG. 259. Natco Front Wheel.

wood wheel, and will sustain more in impact and side thrust. Another advantage is that they may be accurately machined and once round, they will stay so regardless of humidity, heat, etc., that affect most wood wheels. In design these wheels may have the brake drum, hub and flange cast integral so that there are no bolts and rivets to loosen or break. Considering weight, for vehicles of three-ton capacity and over, the steel wheel is lighter than a wood wheel of equal strength, while for two-ton vehicles both types are about equal in weight.

The pressed steel type of wheel for trucks up to two-tons capacity is somewhat lighter in weight than a wooden wheel of corresponding capacity. This type of wheel can be produced for practically the same price as wood wheels, when the complete wheel is considered.

The steel wheels vary in construction, and opinions differ as to which construction gives the best service.

An idea of the construction of wood and steel wheels can be obtained from the illustrations presented herewith and the descriptions which follow:

Fig. 259 illustrates the Natco one-ton front wheel with demountable tire. The wheel has twelve square spokes which are turned into the felloe and retained in the hub by twelve bolts placed between adjacent spokes. The general form of the hubs is largely determined by the dimensions of the bearings and their necessary distance apart. One hub flange is generally made integral with the hub casting, while the other is free to be slipped over a machined cylindrical surface so as to be accurately guided.

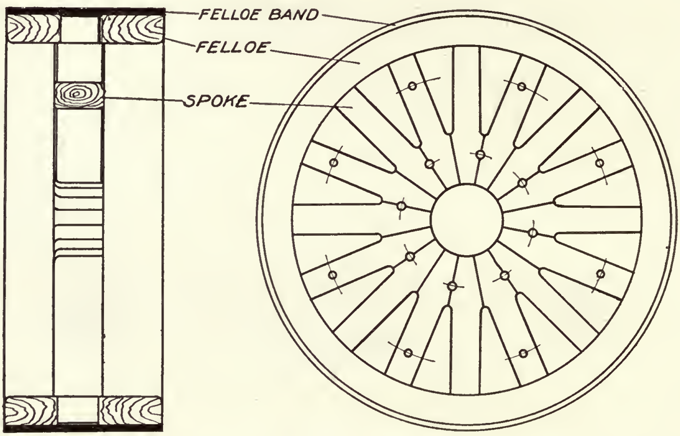


Fig. 260. Mogul Wheel Spoke, Felloe and Felloe Band Assembly.

Fig. 260 depicts the construction of the Mogul six-ton rear wheel which is equipped with 40×7 in. S.A.E. tires. There are eight spokes of rectangular section and eight spokes of square section. These are all of the same thickness, but the rectangular ones are used for attaching the brake drum, and practically the same strength as the square spokes, as considerable stock is removed by the bolt holes. The hub bolts pass through the miter joints of adjacent spokes as shown. The felloe is made to S.A.E. dimensions, and the S.A.E. felloe band is shrunk over it.

Cast steel wheels may be either of the spoke or disc type, and both seem to be giving good results. The disc type either have a single or a double disc, depending upon the capacity, while the spoke type may have either tubular or cross-section spokes.

The single-disc type is at present being used on the Nash Quad Trucks, and this application is clearly shown in Fig. 261. The essential features of this type of wheel are a cast hollow box sec-

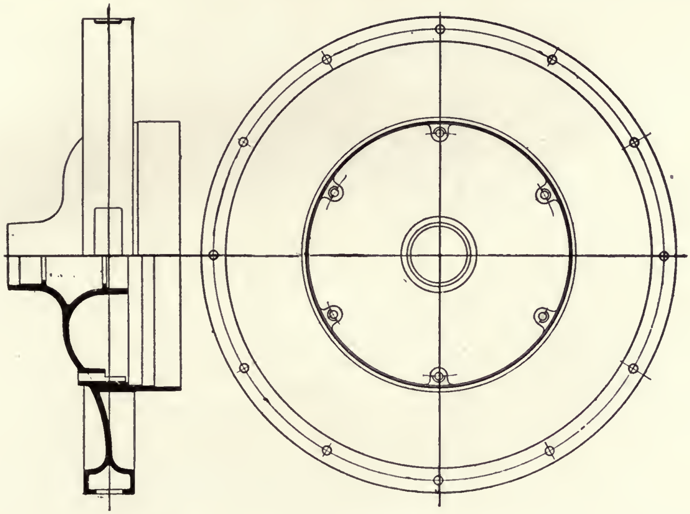


Fig. 261. Nash Quad Cast-Steel Wheel.

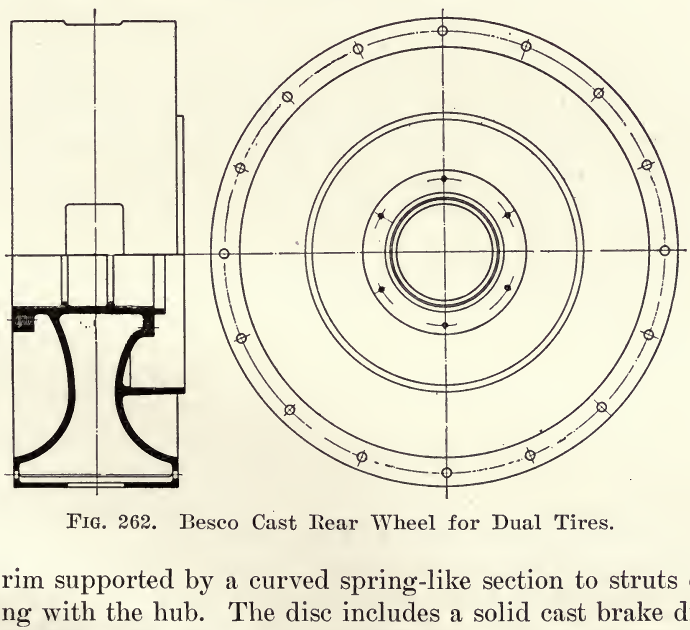


Fig. 262. Besco Cast Rear Wheel for Dual Tires.

tion rim supported by a curved spring-like section to struts connecting with the hub. The disc includes a solid cast brake drum and container for the driving mechanism. The working parts of the drive are thoroughly protected from injury by the wheel disc and brake drum. It will be noted that the hub is cast integral and that there are no bolts and nuts to loosen except those which retain the internal gear.

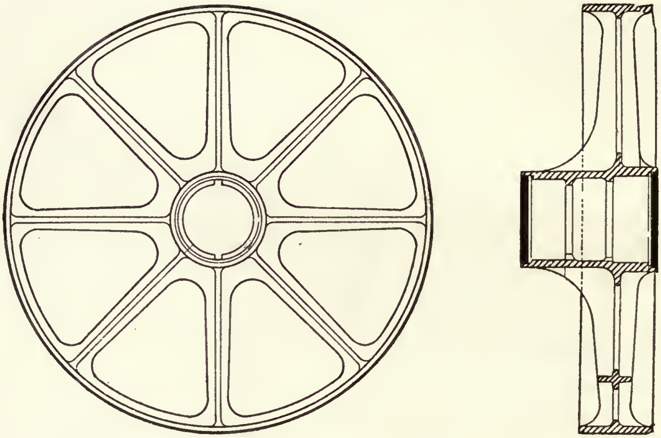


Fig. 263. Spoke Type Cast-Steel Front Wheel.

The double-disc type for heavier vehicles is shown in Fig. 262. The hub and brake drum are cast integral, while the resiliency is obtained through a wide curvature of both discs. The rim is also of box-like section, however, the discs extend to the hub instead of forming a strut at the bottom.

Fig. 263 depicts a spoke type of front wheel with integral hub and rim. There are eight spokes of cross section thoroughly ribbed and fitted to obtain the greatest possible strength with minimum weight.

Fig. 264 shows this type of rear wheel; however, the spokes are of Y-shape, which affords a greater number of supports to the wheel rim without increasing weight, and enables the driving stresses and road shocks to be more equally distributed over the whole wheel.

Fig. 265 illustrates the hollow-spoke type of wheel. These spokes are of tubular section and are connected to the rim by large fillets. The hub is cast integral, while the brake drum may be cast integral or bolted to this type of wheel.

Efforts to decrease the weight of steel wheels for vehicles under two-tons capacity, has led to the building of wheels having the disc and lighter sections of the wheel made of pressed steel, rigidly connected to cast steel hubs.

This construction is shown in Fig. 266. The construction is similar to the cast wheel mentioned above with a box type hollow rim, except that the discs are flanged a little deeper at the rim to

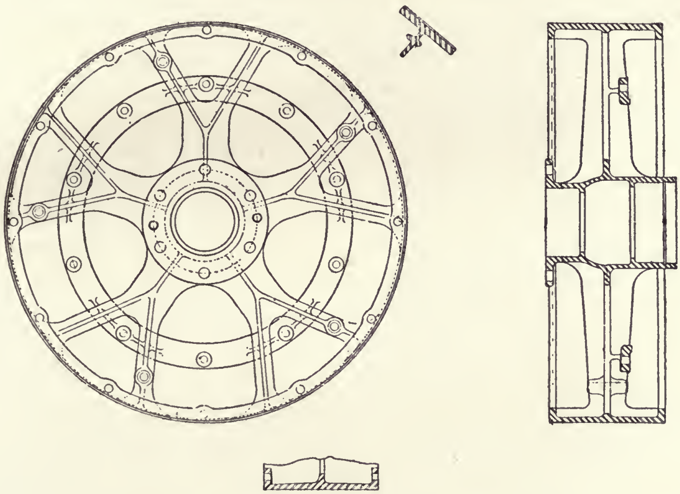


FIG. 264. Spoke Type Cast-Steel Rear Wheel.

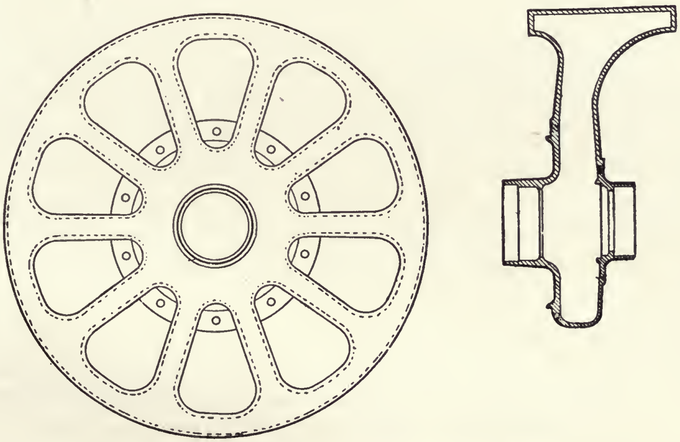


FIG. 265. Hollow-Spoke Type Rear Wheel.

form a wider box section. The cast flange of the hub is carried out further to carry the brake drum and the driving mechanism.

Wheel construction seems to be one of the principal problems on which manufacturers do not agree. The wheels on large capacity vehicles to-day are called upon to carry a very heavy burden at higher speed than ever, and they must also stand the strain due to transmission of power. In order to meet these conditions, the proportions of spokes and felloes have been materially increased, and following the precedent of Europe, cast steel wheels are being considered.

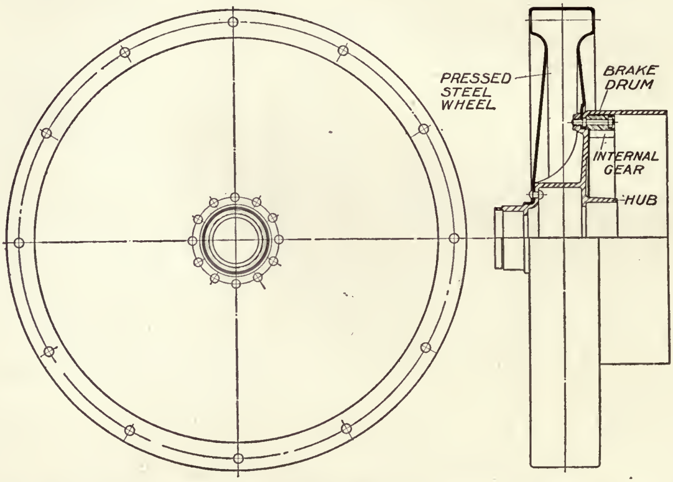


FIG. 266. Pressed Steel Rear Wheel for Internal Gear Drive.

Some advantages of the cast wheel have been outlined above, while of course it possesses certain disadvantages. However, the steel wheel can not be altered for different types and sizes of tires as easily as a wood wheel and a spoke in a wooden wheel, if broken can be replaced; but in this event the entire steel wheel would have to be replaced. Castings are always liable to flaws and blow holes and it is difficult to secure homogeneous metal free from hard spots. Unequal sections cause local variations in strength and internal stresses due to shrinkage in moulding. Where numerous cores are used in moulding, it is difficult to anchor these so that a uniform thickness of metal can be obtained. Strains due to shrinkage can be eliminated to some extent by heat treating. The principal argument against this wheel is that under severe service it crystallizes; however, the design of this type of wheel is of such nature that this so-called difficulty has never existed.

A steel wheel is made in one piece and can be arranged to have an integral brake drum, hub and flange, and there is no opportunity for any working of the various joints. The very nature of this type of wheel adapts it wonderfully to the transmission of power, as the strength lies in the very points where the driving strains are centered.

The absolute concentricity of the hub, sprocket and flange assist greatly in the economical and efficient transmission of power, for with no high and low spots, there is no alternate tightening and loosening of the chain. In shaft-driven vehicles this condition is even more important.

Steel wheels also possess considerable advantage in carrying dual tires. In the case of off-set felloes, the outer tire is entirely unsupported by the spokes; however, in this case the steel wheel is particularly valuable, as the felloe can be so designed that the strains on the outer part can be successively transmitted to the spokes or discs without any danger to the wheel itself. Another feature is the decreased weight at the rim which permits more rapid acceleration.

The advantage of obtaining wheels all assembled and complete for mounting is considerable. No division of responsibility exists as to the mounting of wheels on hubs, brake downs, etc.

Cast steel or pressed steel wheels can be and are made to-day at figures competitive with wood wheels. If the demand increases and they are ordered in large quantities, the cost will decrease. In considering cost it should be remembered that the steel wheel has the hub integral, and the rear wheel may also have the brake drum integral and the cost of these together with all bolts, nuts, felloe band and the labor of fitting them must be added to the wood wheel to get a comparison in price.

From present indications it appears as though the steel wheel will shortly replace the wood wheel on at least the heavy vehicles. The demand is continually increasing, and quite a number of commercial car builders are experimenting with steel wheels.

CHAPTER XXII

MOTOR TRUCK TIRES AND RIMS

In the previous chapters considerable has been mentioned about tires and their functions. However, in this chapter the construction of a motor truck tire and its mounting on the felloe band of the wheel will be described. To be absolutely efficient, a commercial car must be able to carry its load whenever and wherever needed. The vehicle itself may be as nearly as possible absolutely efficient, when measured by this standard, but as a whole it can be no more efficient than its weakest part. Each part must be so designed and so co-ordinated with other parts as to perform in the most efficient manner. In this respect the tires are no exception.

The functions which the tires perform, reduced to their simplest terms, may be listed as follows: (1) To give traction to the wheels and prevent slipping, (2) to protect the mechanism of the vehicle from jars and vibrations, (3) to cushion the load.

Tire Development.—Before the advent of the motor truck, solid rubber tires were used almost exclusively on the wheels of carriages to provide easier riding. On these vehicles the wheels were merely rolling members and performed no tractive effort, as the horses did the pulling. Such tires were held in place by means of wires embedded circumferentially in rubber, the whole unit being mounted on a steel channel shrunk on the felloe of the wheel. These tires were easily applied, but possessed certain disadvantages such as slipping in the channel, cutting at the base and release of the rubber adjacent to the wires.

This type of tire did not prove very satisfactory for heavy vehicles, for the reasons mentioned above. In order to overcome these shortcomings, a new tire was introduced, which was called the side-wire type. In general shape and appearance it was the same as the earlier type. However, it was retained in the channel by means of short cross wires embedded in the base of the tire, which projected on either side. These cross wires were held in place as securely as possible by two other wires running circumferentially around the base just inside the edges of the channel.

With the introduction of the commercial car, an entirely new and different function was required of the tires, that of transmitting the driving power from the rim of the wheel to the road surface, *i.e.*, the tires became part of a tractive rather than a rolling member. Their carrying capacity was also increased because the gasoline engine could move heavier loads than the horse, while the weight of the truck itself was considerably more than the wagon, and the speed was also increased considerably. The carriage type of tire was found entirely too light to perform the work required of it. This condition brought about the invention of the solid motor truck tire, a tire vulcanized in circular endless form to fit the dimensions of the wheel. This type of tire has been brought out in different designs and types such as flange, internal wire, side wire, hard rubber and metal-base types, also the demountable.

Carriage tires were made in oval shape, in cross sections from three-fourths inch and of compound rubber which is formed through a tubing machine die, vulcanized in long moulds with many cavities, in the shape in which it had been designed.

The construction of solid truck tires that have been put on the market is very similar in a general way. The rubber is forced through a die or tubing machine, or built up from sheets of calendered stock in endless form to fit the exact dimensions of a wheel on a particular style of base or retaining body of the tire as designed by the different manufacturers, according to their ideas, which have taken various forms, such as circumferential and side retaining wires which are engaged over embedded cross wires, bases of hard rubber in various forms also semi-hard rubber which can be moulded into the tire and more recently the metal-base type.

This tire is built on the rim at the factory and cannot be separated from it. The surface of the metal rim is cut with grooves, under cut notches or in other ways, so that the hard rubber gets a firm anchorage into the rim. In manufacture this rubber base is applied in some factories in layers, just as you wrap a bandage on your finger. The base is relatively thin, perhaps not one-eighth the radial thickness of the tire. On the top of this is built the regular rubber part of the tire, of softer rubber to afford the desired resilience. This part is also in some factories built up similar to wrapping a bandage until the desired thickness is obtained, which, when done, the tire is trimmed to shape and vulcanized.

Two Metal-base Types.—This metal-base tire is made in two types, the pressed-on and demountable. In the larger cities, the former is quite popular, whereas, in the smaller outlying cities and towns the demountable type has the following. The reason for this is: To remove a pressed-on tire from a truck wheel or put one on a truck wheel requires a powerful press, which means a considerable outlay to the dealer in proportion to the amount of work he may get.

The demountable tire can be removed from the wheel and a new one fitted, without the truck owner having to take it to a garage. Unfortunately it is more expensive than the pressed-on tire, due to the forged and rolled steel parts used with it.

Rubber.—Crude rubber is a vegetable product gathered from certain species of tropical trees, shrubs, vines and roots. It was first used for pencil erasers and in waterproof cloth and finally in solution in cements. Vulcanizing or curing rubber was discovered in 1844; thereafter the development of the industry was rapid, though it was but an infant in size, compared with now, up to the development of the automobile industry.

There are many kinds and grades of rubber, and these may be divided into two classes, wild and cultivated.

Wild Rubber.—This is collected from trees that have grown wild and where there has been no cultivation process. Such trees and shrubs are found mostly in Northern South America, Central America and Central Africa. Fine Para comes from the Amazon region of South America. For over a century this rubber has been gathered in practically the same way. The native goes into the forest, selects a tree, cuts V-shaped grooves in herring-bone fashion around the tree, with one main groove down the center like the main vein in a leaf. The latex of the tree (not the sap) flows from the smaller veins and down the center vein into a little cup placed to receive it.

When full these cups are gathered and brought into the rubber camp, and there the latex is coagulated by means of smoke. This is done by the use of a paddle, which is alternately dipped into a bowl of latex and then revolved in the smoke which seems to have a preservative effect on the rubber as well as drying it out and causing it to harden on the paddle, each successive layer of latex causing the size of the rubber ball or biscuit to increase. When a biscuit of sufficient size has been coagulated it is removed from the paddle and is ready for shipment. There are other grades of rubber which are coagulated by adding some alkaline solution and allowing it to dry out. Central America produces a grade of rubber which is cured by being mixed with juices which are obtained by grinding up a certain plant which grows in that district.

In Central Africa some of the rubber is gathered from trees, but most of it comes from vines and roots, and the methods of coagulation are varied. Practically all of them are dried out in the sun.

Cultivated Rubber.—Cultivated rubbers are obtained from East India, Ceylon, Malayan Peninsula and southern Mexico. The claim is made that the best of these is the Ceylon rubber, which has been grown from sprouts taken from the wild Para trees of South America. These cultivated trees have been very carefully reared and scientific methods used in tapping them, so as not to in any way hurt the bearing qualities of the tree. This product is very uniform, as very scientific methods are used, coagulating, drying and otherwise treating the rubber before it leaves the plantation, so that there is a minimum deterioration due to oxidation and other actions during the time the rubber is en route from the plantation to the manufacturer. Of late, far east rubber is being given the preference, because it is cleaner and contains less foreign matter than the wild para.

Manufacturing Process.—This rubber as it comes into the market, contains a lot of impurities, and before it can be used it has to be washed. This washing is done between rolls which are grooved to tear the rubber apart, water being fed on the rolls to wash off all foreign matter. In this process the rubber loses considerable of its weight.

When the rubber is washed and dried it is mixed with chemicals and into a compound. These chemicals and particles of rubber are placed in metal boxes a couple of feet square. The formula for these compounds are, of course, kept secret by the rubber factories, because they represent the outcome of very long and tedious experiments which are looked upon as one of the chief assets of any rubber mill. These masses of compounds are chewed and rechewed, ground and reground, extenuated and re-extenuated, between the giant steel rolls of the calendering machines that are needed just to thoroughly mix the ingredients. Each compound requires its separate mixing, its special treatment.

The rims to which the hard rubber is vulcanized are in most cases copper plated, as rubber compounds do not take kindly to steel. The hard rubber base is applied to the metal rim and then the tire is completed as previously mentioned.

The compound rubber is in graduated consistencies from the hard rubber base, which forms the inside circumference next to steel base, to the resilient rubber forming the wearing part of the tire.

When the tire is completed it is pressed into moulds which are securely bolted and placed in large cylindrical vulcanizers which vulcanize or cure the rubber. When this process has been completed and the tires have cooled, slight edges remain which are buffed off.

Rims.—Tire rims or metal bases and felloe bands are usually made from flat stock and rolled to shape, and the ends are welded together. Special machinery is used for this purpose and each band or base must check within certain limits. Demountable rim parts are made in a similar manner and must also be held within certain limits.

The Solid-truck Tire.—A number of illustrations are shown herewith, which give the contour and general construction of the solid tire. The Firestone wired-on tire is made and recommended for use on light vehicles only. This tire is not manufactured into the rim as is the hard rubber base type, but is afterwards attached to the rim. Into the base of the tire are placed stout cross wires at frequent intervals. When this tire is placed on a channel rim it is held in place by two circumferential wires, one at each side of the tire, these wires resting upon the ends of cross wires, by virtue of which the tire is retained on the rim. Swinehart manufactures what is called a soft-base tire, with cross wires for holding it in the channel rim. Several other makers also manufacture tires which are retained by cross or circumferential wires.

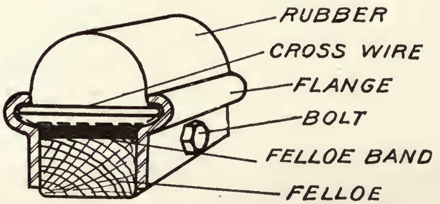


Fig. 267. Republic Side-Flange Type Tire.

The hard rubber base tire as previously mentioned is built onto the rim at the tire factory. This type of tire is being made by Goodrich, Firestone, Goodyear, United States, Republic, Kelly-Springfield, Gibney, Swinehart, Hood, Polack, etc., in the single and dual, pressed-on and by some in the demountable types, some of which are illustrated.

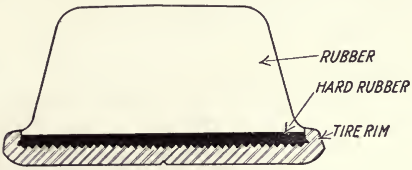


FIG. 268. Republic Pressed-on Type Tire.

These various makes differ in the contour of the tire, the method of producing a firm grip for the hard rubber on the steel and the method of building up the tire, while the demountables differ in rim construction. In some cases the metal base is cut in dovetail fashion and with grooves, such as the Hood, Polack and Goodrich. In the Gibney and Kelly, the hard rubber is carried up to the side of the metal base, while in others it is set straight across the width of the channel base. In some cases the

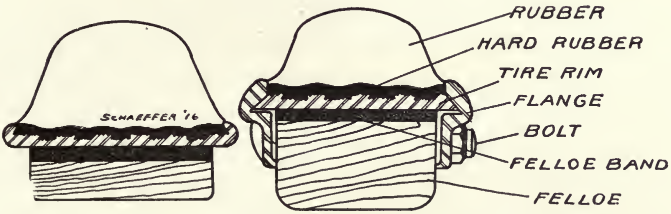


FIG. 269. Goodrich DeLuxe Pressed-on and Demountable Types.

layer of hard rubber is given an irregular wave line surface such as the Goodrich in order to increase the area of contact between the two grades of rubber.

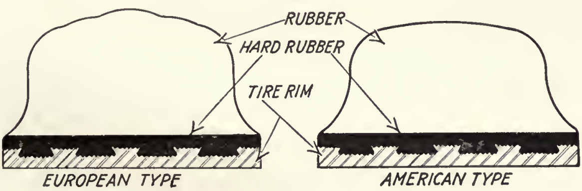


FIG. 270. Polack Pressed-on Type Tire.

The metal base or rim of a demountable tire has the inner circumference tapered from both sides, its smallest diameter being slightly larger than the outside diameter of the felloe band. Rings which have a tapered surface and are usually termed wedge rings, since their cross section is of wedge shape, are inserted between the felloe band and the tire base. These are retained by circular flanges and bolts which pass through these and the felloe of the wheel.

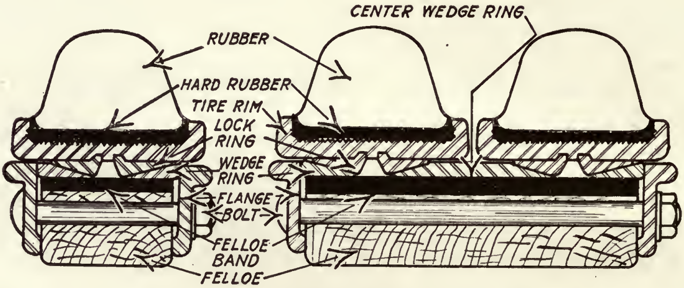


FIG. 271. Kelly-Springfield Demountable Type Single and Dual.

Most tire manufacturers use this construction; however, the Goodrich demountable differs somewhat in that the wedge section is incorporated in the tire base against which the side flanges press. The rubber portion of a solid tire is usually about $2\frac{3}{4}$ ins. high and varies in width according to its design. This, of course, governs the elasticity and cushioning effect. On the large single tires, this height does not give a proper proportioning and to overcome this some makers produce what is commonly called the

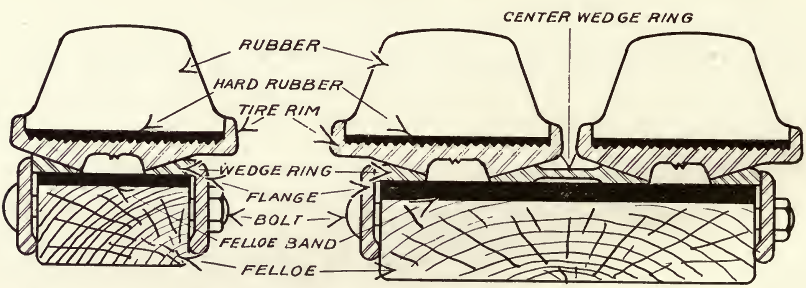


FIG. 272. Goodyear Demountable Type "SV" Single and Dual.

European type of tire, in which the rubber is from $\frac{1}{2}$ to 1 in. higher. The Goodrich Co. calls this their De Luxe type and while it is designed after the European type, it has quite a different contour. Greater resilience is claimed for these types as well as longer life and greater load carrying capacity. A greater carrying capacity is possible, because the contact with the road surface is much larger, consequently the weight is distributed over more base area. The greater height of rubber and increased resiliency also give an entirely different traction hold on the road.

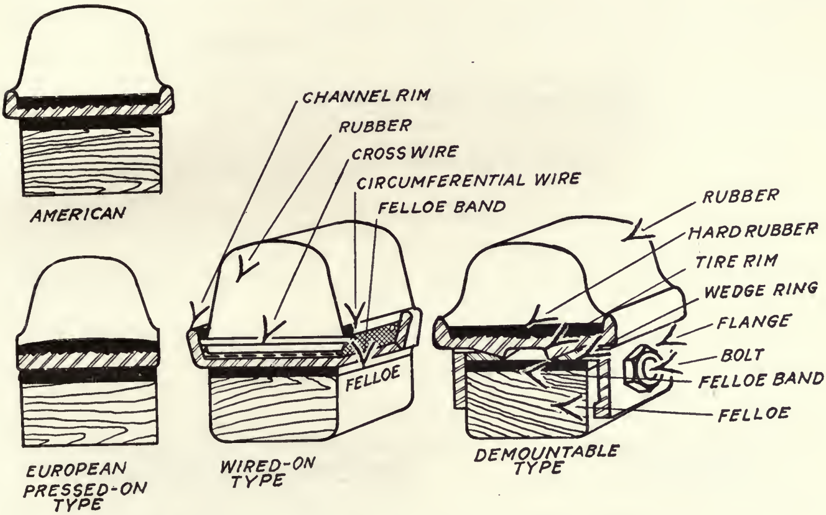


FIG. 273. Firestone's Variety of Solid Tires.

Some tire makers recommend this type of tire as an oversize for the American type, since it is made to fit the S.A.E. standard felloe bands.

The Goodrich Co. has recently introduced a new policy with regard to single and dual tires for heavier truck work. This

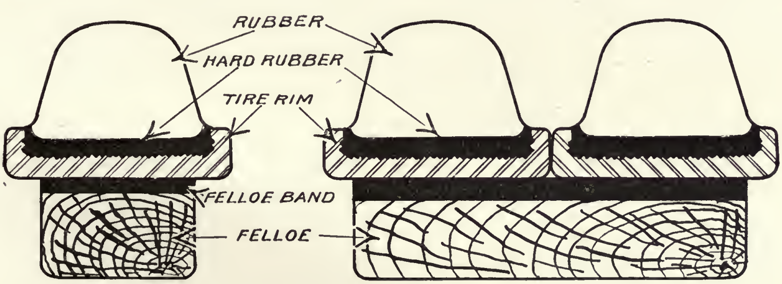


FIG. 274. Goodyear Pressed-on Type "SU" Single and Dual.

company is recommending a 7-in. single in preference to 4-in. duals and 6-in. singles in preference to $3\frac{1}{2}$-in. duals. The arguments are that these singles give better results than the corresponding duals, in that often on the road one of the duals has to take the entire weight of the load on that wheel and that, as it is not designed to take the entire load, it is naturally overloaded and perhaps permanently injured by this frequent caring for the

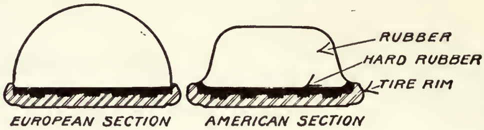


FIG. 275. Hood European and American Section Pressed Type Tires.

entire load weight on one wheel. With singles this is not the case.

Firestone has recently introduced what is known as a giant single solid tire made in 8- or 12-in. width. The extra amount

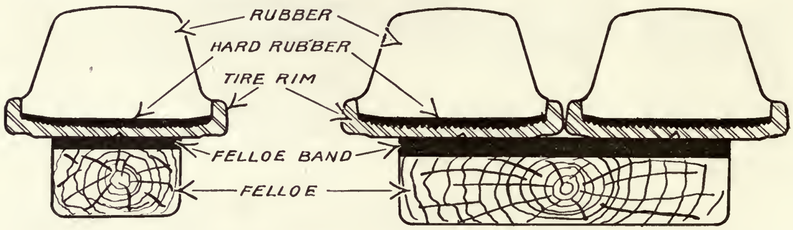


FIG. 276. Kelley-Springfield Pressed-on Type Single and Dual.

of rubber is claimed to make it oversize equipment for 6-in. duals and equal equipment for 7-in. duals. The tread has three evenly spaced circumferential grooves in it.

The Hood Co. recommends its European type of tire for dual equipment, as they claim this type with its greater resiliency will

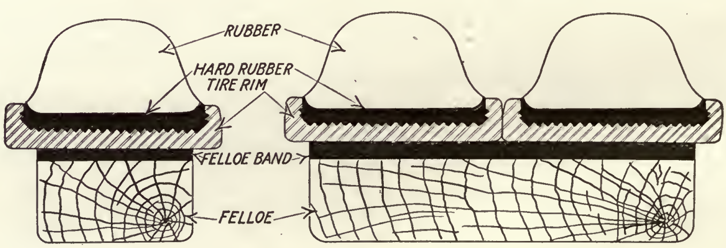


FIG. 277. Gibney Wireless Type "MIB" Pressed-on.

allow the inside tire to compress more and allow the outside tire to take its share of the load.

The pressed-on tire will no doubt gain in popularity as it is less expensive than the demountable type, since wedge rings, flanges and bolts are eliminated, while the firm fit to the wheel also insures the greatest possible mileage. Practically all makers are continuing their demonutables, but the number produced is on the wane. This type will no doubt be continued for some time since powerful hydraulic presses the cost $500 to $700 are required to apply the pressed-on type. This, of course, is a considerable outlay for a dealer in proportion to the work he may get at present. However, the demand for trucks is continually increasing and, in order to assist the dealer in obtaining his share of the business, some tire companies are selling these presses at the rate of $100 down and $100 per year until paid for, on condition that it is used only in connection with tires made by that company.

The claim made for the European type of tire is that owing to its higher section and greater resiliency it greatly reduces the cost of upkeep of the mechanism of the truck, and makes it far more comfortable for the driver.

The Care of Motor-truck Tires.—The care of the motor-truck tire, while an important item in the maintenance of a commercial vehicle, is not generally understood by operators of these vehicles. All manufacturers of solid rubber tires issue instruction books or cards on this subject, but these, like most all other instruction books, find their way into the tool-box and remain there until trouble arises. Tire makers, however, are endeavoring to educate operators on this subject, and since very little mention has been made regarding this, the writer will endeavor to cover it in such manner as to enable the layman to become familiar with the attention tires require, to give maximum mileage.

There have been many refinements in the construction of motor-truck tires, and the majority are very dependable; but tires, like the engine, transmission, axles and all other parts of the vehicle, must have a reasonable amount of attention if one expects to obtain the best results. Tire equipment is given careful consideration by the engineer and the tire maker in determining the necessary sizes and types. However, no provision can be made for the usage of the vehicle or the care of the tires. Provision is made for taking up wear and alignment in the mechanical parts of the chassis which affect the life of the tires. However, these are not automatic adjustments, and require frequent inspections. Tires, like all other parts, have a physical limit, and results can only be obtained if their usage is within the limits of their physical strength, which is based upon the compression of the vulcanized rubber.

For maximum tire mileage, three factors—the tire, the road and the driver—must be considered. The tire must be considered because the type of tire used for quick delivery cannot be used for heavy duty. The road naturally effects the mileage of truck tires, because the bumps and ruts of bad roads throw localized shocks on them. The driver, next to the tire itself, is the most important factor. It depends upon him whether the truck be abused.

In the following an outline of the common injuries to motor-truck tires is given, most of which are sustained in running, and may be traced directly to one of the three factors mentioned above. These common injuries may be summed up as follows: Overloading, speeding, rough roads, wheel alignment and irregularities, anti-skid devices, neglected cuts, skidding and application of brakes, application of power, running in car tracks, heat, oil and grease and abuse of trailers.

The most premature tire failures are due to overloading, not only by constant overloading, but by the momentary overloading as well. Rubber, like any other material, has its limits of resistance, this resistance being its ability to return to its original shape after being compressed. This may be compared with an ordinary rubber band, which will snap if stretched beyond its limit of elongation, as the rubber in a motor-truck tire will snap at once, even though momentarily loaded beyond its limits of compression. This compression is noticeable by the bulging out of the rubber, both left and right and even front and rear. If the load is within the capacity of the tire the rubber will withstand the strain and as the load is released, return to its original shape, the same as a rubber band when stretched and released. However, if the load is beyond the capacity of the tire the rubber will break down as inevitable as when stretched beyond its limit of elongation. If the tire is overloaded momentarily the rupture may not be apparent, as the broken portions may be hidden by others not noticeably affected, yet the strength of the tire is impaired and failure of the whole structure is merely a matter of a short time, as the damage is bound to spread.

The distribution of the load also has an important bearing upon the life of a tire, as trucks are frequently loaded so that the heavy articles are carried near the tail-board, while the forepart of the body carries little. In this case the rear tires usually carry an overload, although the total load may be within the capacity of the vehicle. Loads which overhang the rear of the body, such as lumber, pipes, etc., also produce the same effect. It does not matter whether the overload is a constant one or a momentary one as far as the cause of the damage is concerned, and is only material to the extent of the damage. A momentary overload may have ruptured the tire structure only in a single

FIG. 278. Overloaded, Overspeeded and Bad Road Tire Effects.

spot, whereas a constant overload will damage the whole tire, thus hastening it to complete failure; but in both cases the tire is doomed to premature ruin.

Small dual tires are often exposed to momentary overloads, as the camber of the road may be such as to throw the total weight alternately on one of the outer or inner tires, the mates being momentarily relieved of their load.

Speeding.—A tire which is overspeeded is prematurely destroyed in a manner very similar to that of an overloaded tire. Overspeeding makes every road rough, because it magnifies every irregularity and this increases the effect of all shocks. Hitting a curb, bump or any other obstacle with considerable impetus, even though the truck be empty, is in effect identical with a momenary overload, causing a rupture in the rubber structure in that particular spot and gradual ruin of the tire, for as the wheel revolves at excessive speed the rapidity of compression and expansion of the rubber generates internal friction heat. This is increased considerably by the friction of the road, thus heating the rubber to a higher degree than it can resist. This combined with the increased effect of all shocks is very destructive.

Rough Roads.—Rough roads have an effect on solid rubber tires similar to that of overloading and overspeeding, as the face of the tire rests successively on irregularities which have the effect of overloading that particular portion of the tire. These irregularities, such as ruts, large stones, crushed stone, loose brick and similar road materials, cause shocks which tax the tires beyond the limit of their power to absorb them and these momentary overloads create a disintegrating effect upon the tread of the tire. Some roads have an extreme heat which also causes disintegration while others produce a similar effect, owing to their composition. Careful driving over rough roads at moderate speed, avoiding ruts, stones and loose surface material as much as possible, will greatly increase tire mileage.

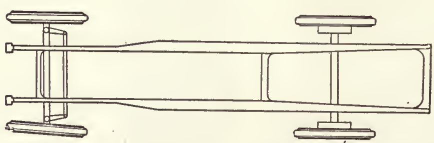


FIG. 279. Front Wheels out of Line due to Striking Curb or Obstacle on the Road.

Wheel Alignment and Irregularities.—Any fault in alignment allowing the wheels to run out of parallel no matter to what small extent prevents their true rolling motion. When two opposite wheels are not parallel there is a diagonal grind upon these at the point where they come in contact with the road surface. This grinding action quickly wears off the rubber, the wear being very smooth just as though the rubber had been ground off on an emery wheel.

Misalignment of wheels generally is evidenced through excessive wear on one side or by flats, as these when once started rapidly develop. There are a number of things which affect the alignment of front wheels. The cross rod, axle, or steering knuckle may be bent due to violent contact with the curb, another vehicle or obstacle, the cross-rod or knuckle may be improperly adjusted, loose or worn hubs, bearings in the wheels and bushings in the steering linkage may be worn, or the adjustments may have been disturbed through vibration.

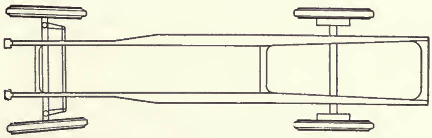


FIG. 280. Front Wheels out of Line due to Wear or Improper Adjustment.

All wheels should be frequently tested for alignment and always after a collision or untoward event that is likely to effect the wheel adjustments. A piece of tubing fitted with a sliding rod and a thumb screw, or a stair tread extension rule, form a useful gage for front wheel testing. In testing front wheels it is most important that the dead vertical center is measured, both front and rear. This is necessary because of the tendency of the front wheels to spread under the driving force and it is the practice of commercial vehicle builders to set the front wheels at a toe in from one-fourth to five-eighths in. less in front of the axle than in back of it. This allows one-eighth in. to five-sixteenth in. toe in for each front wheel. This is practically taken out by the action of the vehicle on the road, for under momentum the wheels will be approximately parallel.

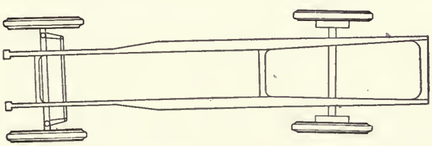


FIG. 281. Rear Axle out of Alignment due to Poor Chain Adjustment.

Each wheel can also be checked up separately by raising it with a jack and placing a stationary point almost against the wood felloe. Revolving the wheel will determine if the distance between the stationary point and the felloe is the same at all points around the wheel. If the wood felloe rubs at some point around and not at other places it may be due to a slight variation in the felloe, but more usually it is the result of a wheel not running true.

Irregularities of the driving wheels of a motor vehicle do not exist to the extent that is the case with the front wheels, though it occasionally occurs that when the rear axle is displaced to one side or the other it causes the wheels to take up a diagonal position with a consequent grinding action upon the tires. It is essential should it be discovered that these are out of parallel that the trouble be rectified immediately. For testing rear wheels, both comparatively and their relation to the front wheels, the ordinary line and rod method cannot be improved upon. The measurement between the wood felloes of the rear wheels should be the same both in front and rear wheels of the axle. Whenever an undue amount of play is discovered in the wheels steps should be immediately taken to remedy the defect, otherwise irreparable damage to the tires is inevitable.

Anti-skid Devices.—Anti-skid devices, especially those which are stationary upon the wheel, contribute a great deal toward causing solid rubber tires to give unsatisfactory service. The loose chain is by far the least injurious as it will work its way around the tire and equally distributes the wear and strain. However, with a stationary chain this is constantly confined at the point of bearing.

These anti-skid devices are mostly applied to the driving or rear wheels of a vehicle and these are quite apt to spin in slippery places, causing sharp blows at the points of contact. With a sationary device the shock received by the tires in striking the ground is concentrated in a few points around its circumference, causing heavy strains at these points. In order to avoid this, devices having numerous cross-pieces should be used for as the distance between these is decreased the force of the blow decreases as the wheel gains momentum. Every type of anti-skid device is more or less injurious to the tire and they should only be used temporarily to pass over soft slippery places.

Neglected Cuts.—Cuts are of common occurrence and are generally caused by road conditions. These cuts, no matter how small, afford an entering place for sand and fine gravel, causing the cut to increase in length and depth. Sand, gravel and other gritty substances are enemies of rubber and once they effect an entry into the tires it is pretty hard to combat them. Cuts near and at the edges are most injurious, and if attended to in time are easily remedied. These should be trimmed off smoothly with a sharp knife as soon as they occur, and if they are not trimmed the revolving wheel causes the loosened edges to catch on every obstruction, so that the tear constantly increases. When one unit of a dual tire is permitted to weaken in this manner it causes an overload on its mate.

Skidding and Application of Brakes.—Skidding is generally caused by sudden application of the brakes, turning corners too rapidly and turning corners so small that the crown of the road may cause the rear wheels to skid. The effect of skidding or locking the wheels is quite serious, as this causes flats on the tread of the tires, in addition to placing the tires under side strains, which tears them loose from the base. This same condition will also exist if the brakes do not grip evenly, causing one wheel to roll while the other drags. Turning corners too rapidly increases strain and wear on the tires with a similar effect. Some tire makers recommend truing up tires if flats develop, by turning down the tread, otherwise these will develop rapidly and cause a great loss of mileage.

The sudden application of power by quick engagement of the friction clutch produces the same effect as locking the wheels. The power applied at the hub starts the rim first and the resistance of the road prevents the tire from starting at the same instant. This brief delay slightly stretches, displaces or strains the rubber, just as the life is taken out of a rubber band by continual stretch. This danger is greatly augmented as wear takes place in the driving members, such as the hubs, universal joints, driving chains, etc.

Running in Car Tracks.—Injuries resulting from running in car tracks are serious and readily apparent. Under this condition, the outside edge of the tire rests upon the raised edge of the car track, so that the distribution of the load is on but a small portion of the tire. That is, the weight of the vehicle is being supported by that small portion of the tire which is riding on the raised part of the track. Throwing the load upon half of the tire causes it to wear rapidly, while the rest of it is in apparently good condition. With dual tires this effect is still more pronounced because that part of the unit riding on the car track must sustain the load intended for both tires.

Heat causes disintegration of the rubber. In winter the large garages are generally heated by steam, the headers of which are fastened close to the ceiling of the floor below. This heats the floor above to quite an extent, and if a heavy truck is parked for two or three days directly over a big hot spot in the floor a condition is developed that results in a flat being formed in the tire shortly afterwards. This is due to the action of the heat softening the rubber, while the weight of the truck is resting upon it, causing a flow that never fully returns.

Gasoline, oil, grease and other fatty substances are solvents of rubber. If garage floors are not kept clean and the tires stand in a pool of oil, a similar action to that of the effect of heat will take place. Grease and oil can easily be removed by a rag saturated with gasoline. Gasoline, although a solvent, evaporates quickly and if applied in small quantities will not cause any in-

Fig. 282. Tires Showing Undue Wear.

jury if used as a cleansing agent. Another difficulty occurs in the abuse of trailers, which is caused by turning too sharp a corner while loaded. The effects of this are similar to those caused by skidding, as it tends to wrench the inside wheel, twisting the tire, which is firmly held to the road by the weight of the load. The results are a loose tire in a very short time.

The above gives the general abuse of commercial vehicle tires, and while there are numerous others of minor importance, it has been proven by maintenance engineers that many tire miles can be saved by avoiding the above sources of trouble. In order to obtain maximum tire mileage, commercial vehicle owners should instruct operators to avoid all overloads, momentary ones as well as constant ones, speeding, curbs, ruts, car tracks and reckless backing up against curbs, and also to properly distribute the load and to select the best roads and smoothest pavements.

Truck operators can save a considerable amount by using judgment in the operation of a commercial vehicle.

CHAPTER XXIII

ELECTRIC LIGHTING AND STARTING ON COMMERCIAL TRUCKS

The Advantages and Disadvantages of Electrically Equipped Trucks.—Is electric lighting and starting equipment justifiable on commercial cars? Many engineers consider it an unnecessary complication; others hold that with it economy as well as convenience is gained. A résumé of the advantages and disadvantages may prove interesting especially since the Government specifications for the military trucks included this equipment.

Many mechanical problems must be considered in selecting electrical equipment for commercial cars. While these units have worked out satisfactorily for passenger vehicles that are equipped with pneumatic tires, it is a question whether they will endure the greatly aggravated vibration of motor trucks having solid tires, stiffer springs and are compelled to travel cobble-stones and rough roads. Such consideration as frequent troubles from inability to withstand the hard usage, are very important and may more than offset the advantages gained through the use of such equipment. It is true that some of these equipments have worked out very satisfactorily on commercial cars; however, they are generally designed to meet these more exacting conditions. They are sturdier and stronger built devices, while the battery must also be of such capacity as to permit frequent starting and must have some special mounting to resist vibration.

The arguments for and against electrical equipment, covered in the following, are the result of a general study of this subject and are not based on the opinions of makers of these units.

Four units generally comprise the complete electric system, the ignition system, the generator, the starting motor and the battery. Ignition systems were previously described and will not be considered in this article. The generating system consists of a generator or dynamo, its drive and mounting and also an output regulator and reverse current cutout. The starting system consists of an electric motor, its drive and mounting and a suitable switch for starting purposes. The link between the two systems is the storage battery which serves in effect as a reservoir for accumulating electricity.

The generators of different systems now in use vary in construction or type, some having a permanent and others an excited or wound field. Fundamentally, there are three types of generators in use—shunt wound, compound wound and differentially wound generators. The field itself may either carry simple or compound windings. The armature revolving between the poles of the field generates electric current, the output of which is governed by the output regulator. The method of generating electric current was described previously in the chapters of magnetos. The reverse current output prevents the flow of current through the generator from the battery.

The starting motor which takes the place of the ordinary hand crank is operated by current from the battery. This unit is similar but opposite to the generator in that instead of motion producing current, current flowing through the fields energizing them and causing the armature to rotate produces motion. Speaking loosely, electricity that has been pumped into the battery by the generator, runs out through the motor. If the motor is properly interconnected with the engine it can be made to turn the latter over until it starts.

A definite amount of work must be done to produce electricity, and that work is done by the generator. The electrical energy that the generator produces is stored in the battery for use when the generator itself cannot supply the current as when the engine is to be started.

Advantages of Electric Lights and Starter.—The advantages on a commercial vehicle of electric lights and starter are as follows in their order of importance:

1. Greater economy due to saving gasoline and time when many stops are made by not keeping the engine running.

2. Increased life of the engine, as shutting it off at each stop, eliminates considerable needless wear.

3. Saving of time over hand starting increasing the actual working hours of the car and operator.

4. Better lighting and easier driving for night work and fewer accidents from the rear light going out.

5. Better finished appearance of cars for certain classes of work.

To these may be added the possibility of getting more for certain types of cars for special service, where the advertising value is considered.

Disadvantages of Electric Lights and Starter.—The principal disadvantages in equipping commercial vehicles with these units are:

1. Additional first cost and added complications which the driver does not comprehend.

2. Increased maintenance cost and interest on additional investment.

3. Decrease in engine accessibility in making repairs, thus increasing the cost of these repairs.

4. Unreliability of certain parts, such as the storage battery and the possibility of these units being maintained far below their original efficiency.

5. The effect of vibration on units not originally designed for commercial car service.

6. Inability to keep the battery sufficiently charged owing to frequent starting and stopping.

7. Battery and other electrical troubles aggravated by the average commercial car driver not being familiar with the construction and care of the electrical system.

On trucks that have many stops to make such as house to house delivery, starters are no doubt desirable, considering the high cost of gasoline, as the operator will invariably allow his engine to run rather than crank it when making a stop of a few minutes. Stopping the engine will cut down the fuel bills.

But whether the starter will save time over cranking seems to be disputed. Various arguments are advanced covering the point of economy.

Any type of delivery car and even some of the large motor trucks make more stops during the day than the average touring car, and from the point of economy the commercial car would seem to have the greater need for a starter. Moreover, the starter is also a convenience and saves energy. Some imagine that the starter will start the engine when the driver cannot start it. This is not true unless the engine is too big to be spun by hand. The average truck engine can be spun easily by the average driver and if the gasoline mixture is getting to the cylinders and the spark is all right, it can be started as many times by man as by a self-starter. A self-starter can do no more than man, but it does conserve his energy.

Some claim that the time saved with a starter even when stops are numerous is relatively small compared with the time the operator usually wastes in other directions. Cold weather must also be considered, which may average four months per year, when it is really advantageous to let the engine idle and prevent the radiator from freezing and to keep the mixture warm for a good start.

Stopping will increase the life of the engine, but in the absence of a starter with a bonus system to encourage economy, the driver would not let the engine run idle for long. Where, especially on the heavy vehicles, the drivers' union compels the owner to provide a helper on each car, there is still less excuse to keep the engine running.

Without question, electric lights are preferable to oil lamps, but it is for the owner to decide, especially whether they are worth their slightly greater cost if there is little operating at night. Accidents that may be traced to the lighting system will be reduced, if the lighting system is maintained at its original efficiency, which is doubtful on a commercial car.

Where appearance is a large factor, the additional first cost and maintenance are usually disregarded. Under certain conditions, especially on light deliveries, electric equipment adds considerable to the sales value. Conditions here approximate those of a touring car and there is no question of that feature in this case.

Disadvantages Discussed.—The first cost of a commercial vehicle is what engineers have been striving to keep down and simplicity aids low first cost. Electrical equipment will add a certain amount of weight and expense that must be paid by the purchaser and as a motor truck is purely a business proposition, its prime object being to carry goods at the lowest cost, the starter must save time and money. From the mechanical viewpoint it means some complications that the average truck driver does not comprehend. He is not an electrician and the best electrical equipment requires some electrical knowledge at times.

The question resolves itself into whether starters can save enough in fuel and time to offset the increased maintenance cost and pay an interest on the additional investment. It should also be remembered that this added equipment will render the engine more inaccessible for repairs, thus adding to their cost.

There are certain objections from a mechanical standpoint. The battery seems to be the weakest unit of the entire system, for this is subject to jolting and jarring, which shortens its life perceptibly even with the best of care. Spring mounting devices may overcome this difficulty, but a vast amount of education is necessary before the average truck driver will know how to take care of a storage battery. Even after this lesson has been taught, there still exists that human element which is responsible for the rapid destruction of commercial vehicles through improper care, handling and neglect.

Frequent starting and stopping is another factor which also must be given consideration, as the battery must be of ample capacity to provide for the number of starts made during a day's work. The generator must be of sufficient size to keep the battery properly charged and it must be also of the simplest type.

The difficulty resulting from the driver's lack of knowledge will probably diminish as use of the system becomes more universal.

Opinions of engineers differ as to the final solution of the problem. At present the question of electrical equipment seems to be up to the public, as the personal view of the purchaser appears to be the greatest factor. All makers supplying electric units as regular equipment will omit these if requested to do so. Makers, who do not regularly equip their vehicles with these units, will supply them, if the owner will pay the difference.

The battery seems to be the troublesome unit and the weakest point of the entire system. So far as the lighting is concerned the problem may be solved by sending current directly from the generator to the lamps, similar to the Ford car, but without its irregular lighting characteristics. The starter problem is more aggravated, but may be solved in some as yet unfound, but equally simple, way.

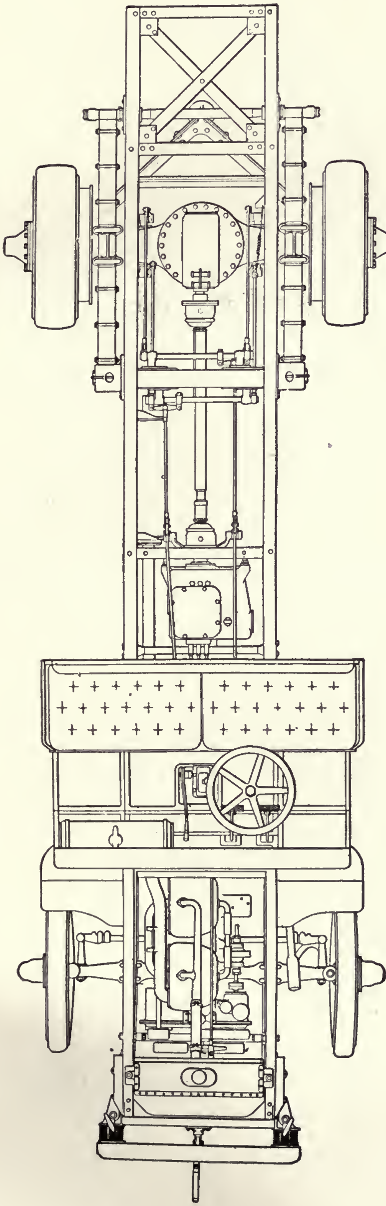


FIG. 283. Plan view of the Liberty Class B chassis, showing Hotchkiss drive and massive construction for heavy duty.

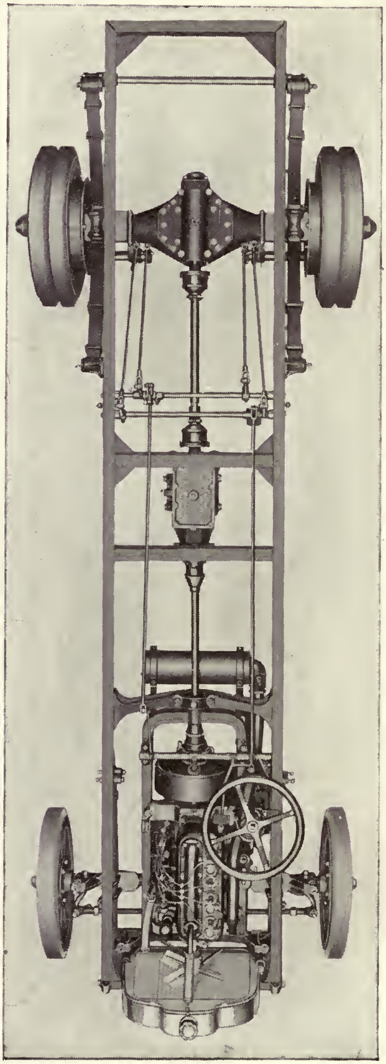


FIG. 284. Plan view of the United States Truck, showing floating power plant.

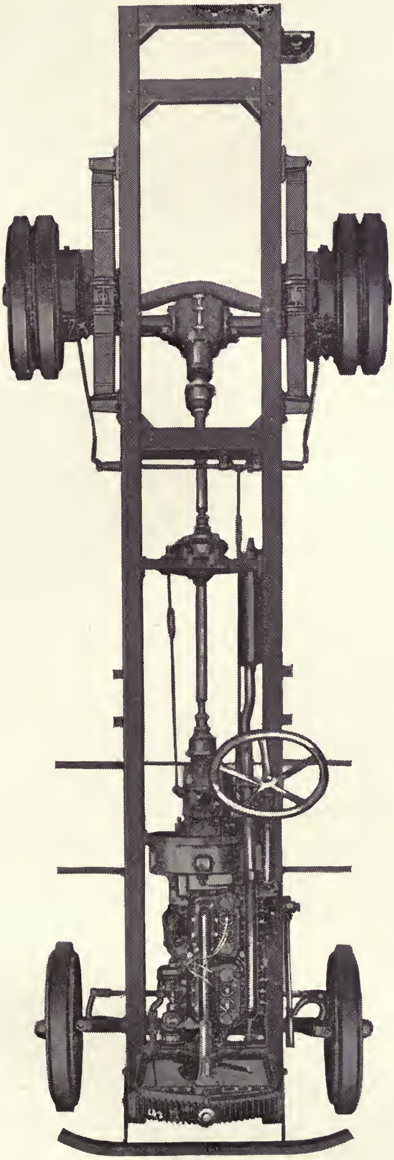


Fig. 285. Stewart $3\frac{1}{2}$-ton chassis, plan view, showing internal gear drive axle and unit power plant.

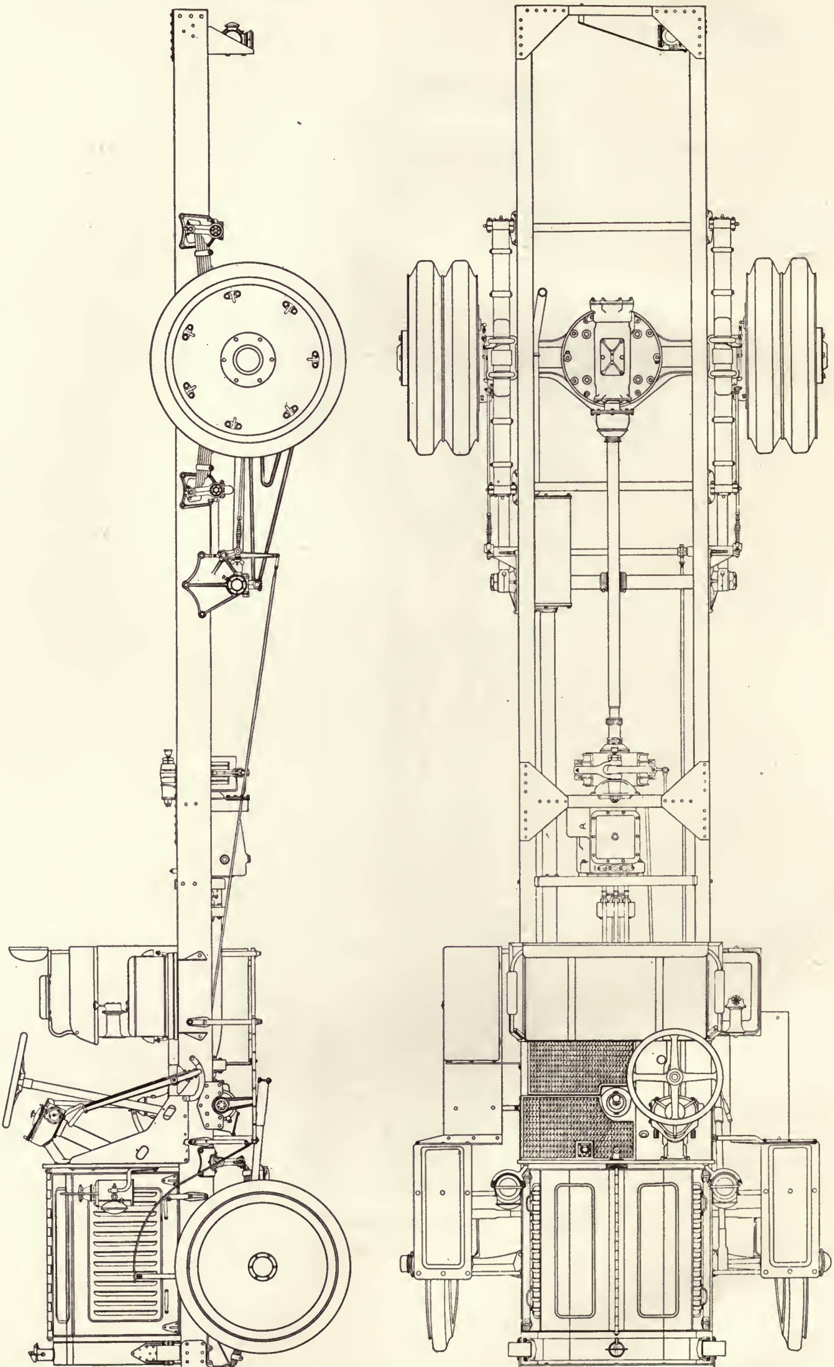


FIG. 286. Plan view and side elevation of the Packard 5-ton worm-drive chassis.

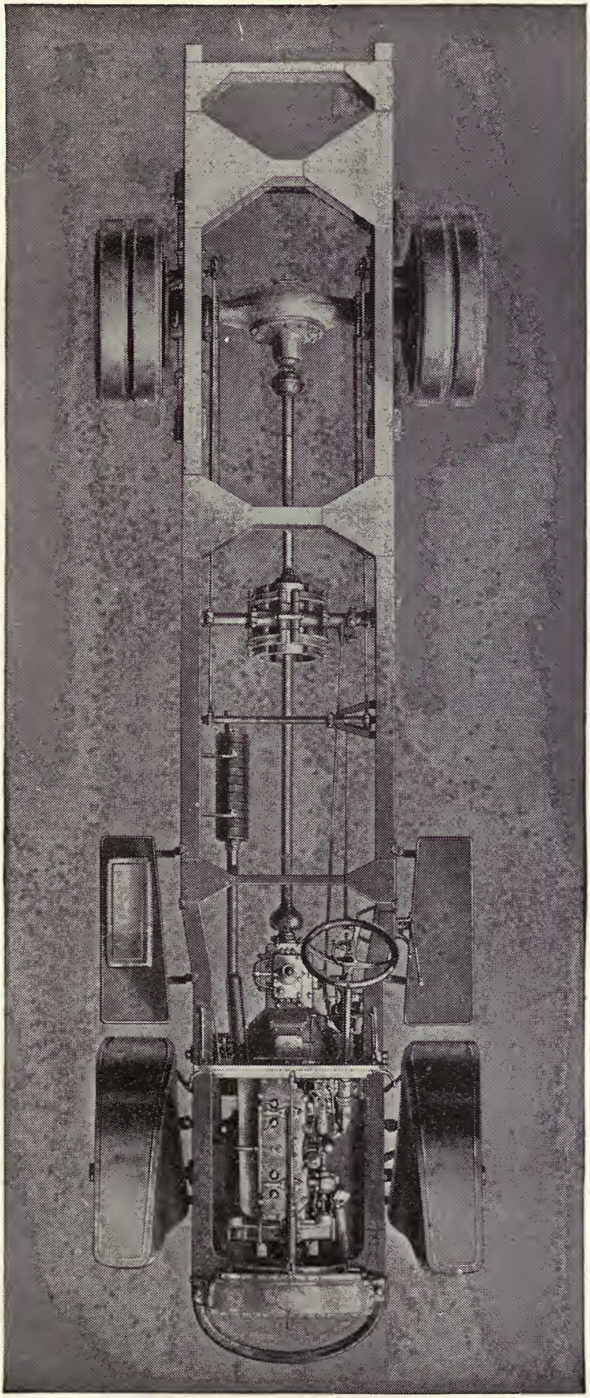


Fig. 287. Plan view of the White 5-ton chassis with double reduction rear axle.

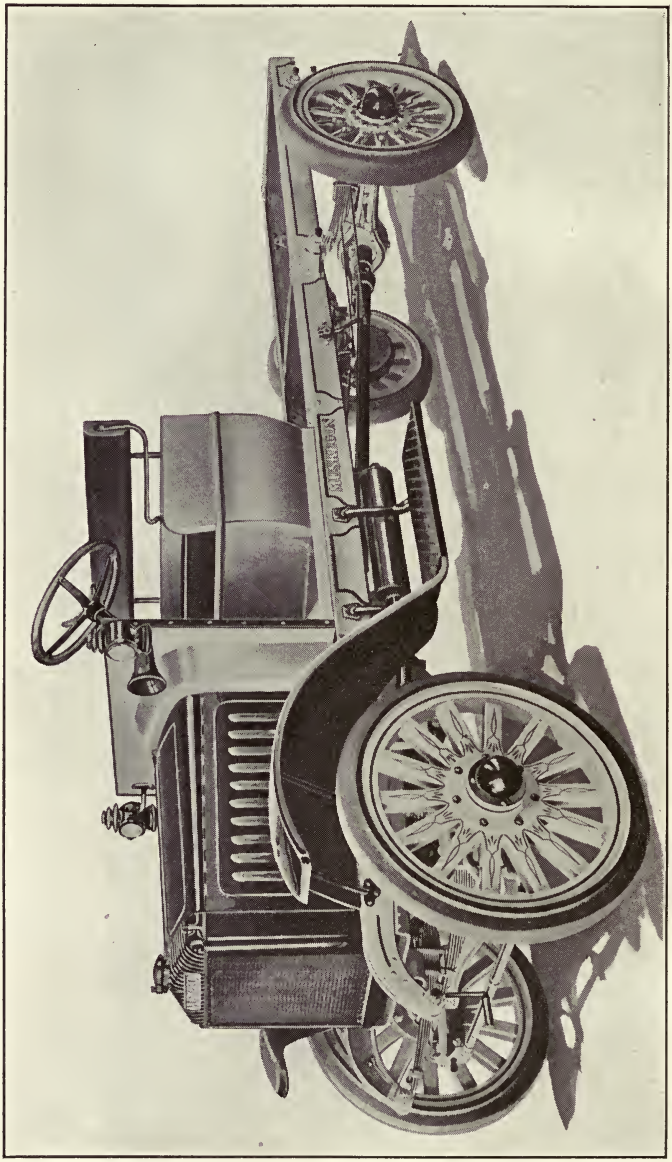


FIG. 288. Muskegon 2-ton chassis.

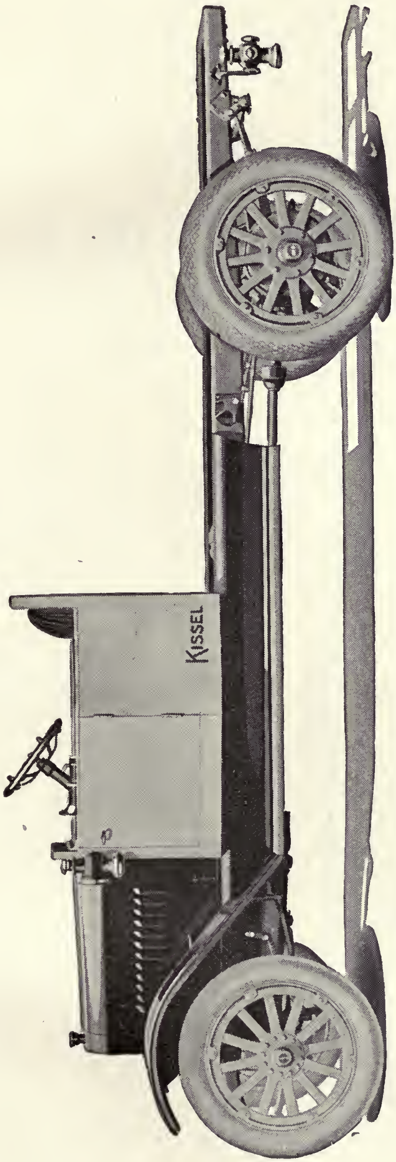


Fig. 289. Kissel General Delivery Truck, $\frac{3}{4}$ to 1-ton capacity.

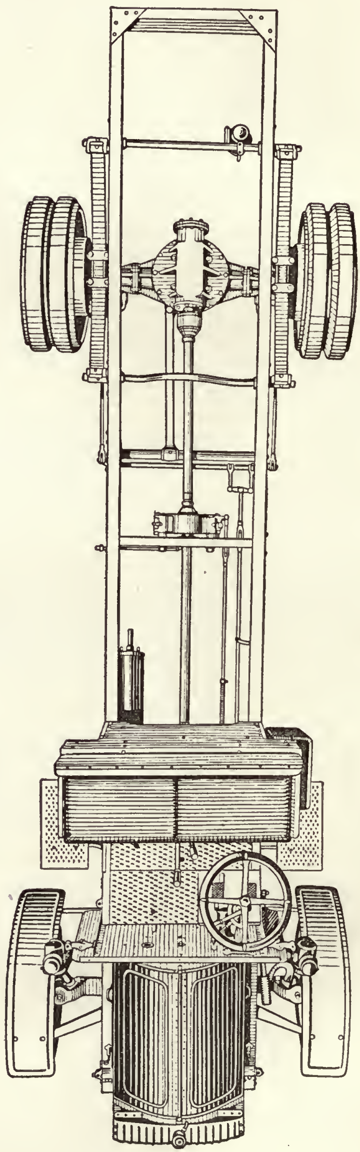


Fig. 290. Plan view of the Schacht worm-drive heavy duty chassis.

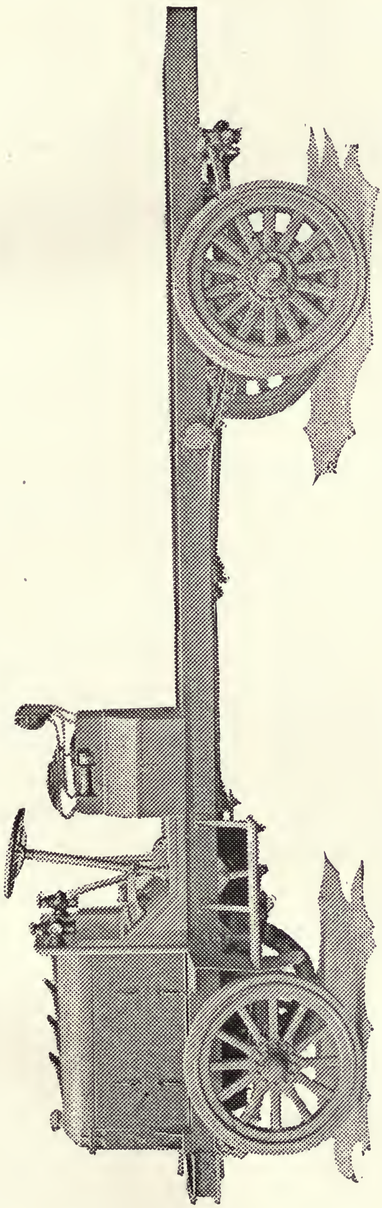


Fig. 291. Side View of the Fageol Heavy Duty Chassis.

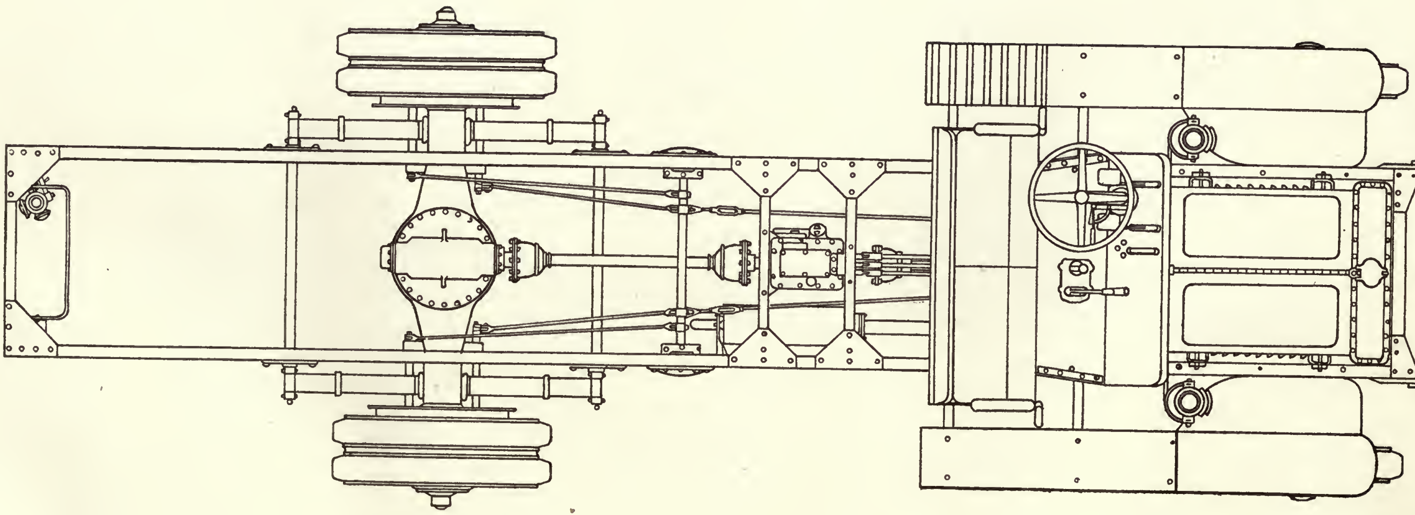


FIG. 292. Plan View of the Federal $3\frac{1}{2}$-Ton Chassis.

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APPENDIX.

List of Plates.