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The CONSTRUCTION OF A

Gasolene MOTOR Vehicle

C. C. BRAMWELL

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INTRODUCTION

THIS work is intended to supply the want of a handbook on the *Gasolene Motor*, and is the result of a series of articles on that subject, written by Mr. Clarence C. Bramwell especially for the Motor Vehicle Review. My work has been merely that of editor, and I have taken only such liberties with the original text as seemed conducive to greater lucidity, having in mind the purpose of instruction for the uninitiated.

The general information contained herein will be found of great value to manufacturer and buyer, as well as to the mechanic and to the amateur builder.

As the principles involved in all four-cycle gasolene engines are practically the same, an exact knowledge of the mechanism and construction of one will enable even the novice to understand any make or style now on the market.

The drawings are mechanically correct, and a reference to the figures and letters on them will clearly and distinctly describe their intent.

The vehicle shown has actually been built, and has given satisfaction.

E. W. GRAEF.

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CHAPTER I.

Principle on Which Motors Operate.

We will begin with the motor because it is the foundation of any vehicle, and we will describe the different operations that, taken together, make up the complete working cycle of any gasolene engine. Frequently a man will have trouble with a gasolene motor because he does not fully understand the principles upon which it depends for its successful operation.

A successful gasolene motor consists of a cylinder, C, a piston, P, a crank, A, a connecting rod, R, a flywheel, F, figure 1. The power of the engine depends upon the expansive force due to the heating of the gases in the cylinder, and behind the piston. The heat is generated by the combustion (or burning) of a gas and air mixture previously introduced into the cylinder.

In small motors this is usually done by turning the crank, A, by hand, thus pulling the piston, P, toward the outward or crank end of the cylinder. This action reduces the pressure within the cylinder and as the outside or "atmospheric" pressure is greater it forces open the inlet valve, I, which will remain open until the pressure is relieved when the spring on its stem will come into action and close it, at about the end of the outward stroke. The exhaust valve, E, will not open during this stroke because (as is seen in figure 1) it is held closed by a much more powerful spring.

Our cylinder is now filled with a gas that passed through the pipe connecting with the inlet valve, I, while said valve was open. Reference to figure 2 will show diagramatically the position of the piston within the cylinder at this point. It would be futile to ignite the gas now because the crank, A, is at the end of its throw, so we rotate the crank another half turn, and this brings it back to its original position. We have now not only brought the piston and crank to their

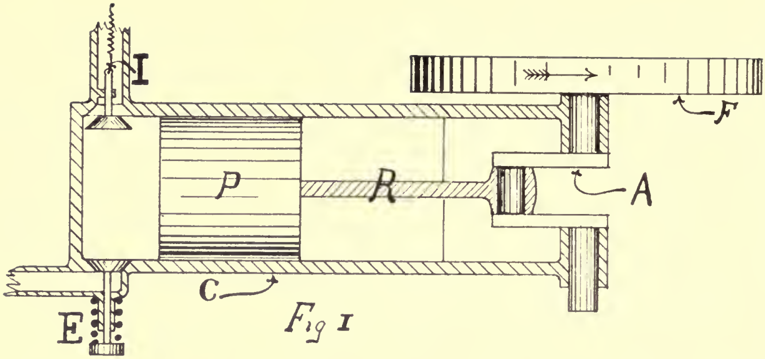

Fig I

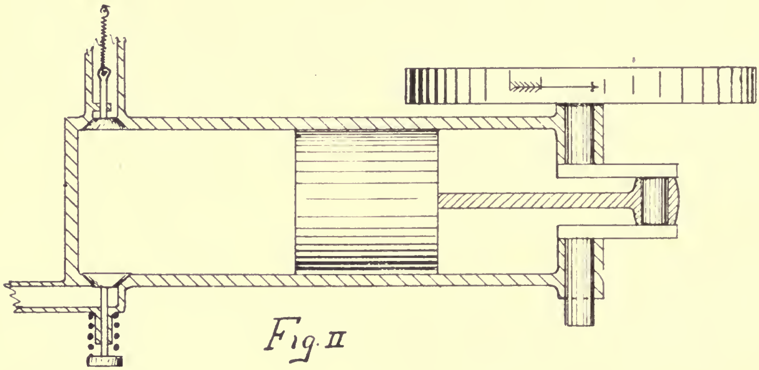

Fig. II

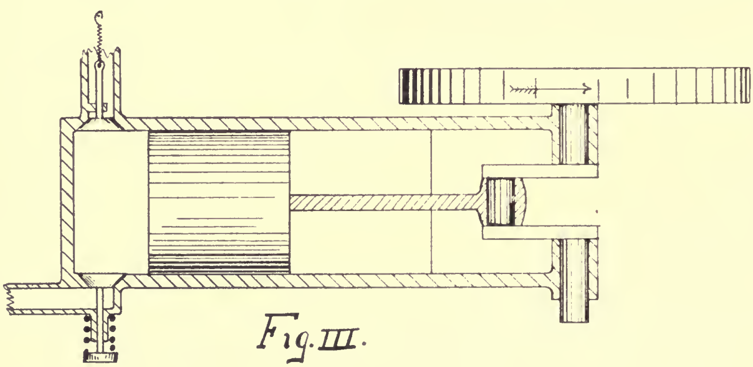

Fig. III.

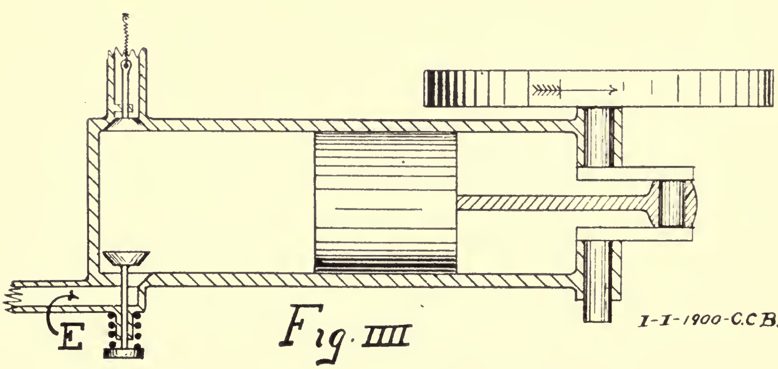

Fig. IIII

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proper positions for the next stroke, but at the same time we have completed the "compression stroke," thus rendering the contents of the cylinder more inflammable, so that when once ignited the flame will be propagated throughout the whole contents much more readily than would be the case were it not for the compression. Owing to the compression we will have much greater pressure on the piston on the next outward or "expansion" stroke.

Reference to figure 3 will show the state of affairs at the beginning of the second outward or the explosion stroke. It will be noted that the same amount of gas that previously occupied the cylinder is now compressed in the back end thereof, which is known as the "clearance space." This space is equal to about one-third of the interior contents of the cylinder, and in it we now have the gas compressed to about 45 pounds per square inch. After turning the crank slightly over the dead center we are prepared to ignite the gas that is compressed within the clearance space; say by means of an electric spark.

When the gas mixture is ignited its temperature will suddenly rise to something over 600 degrees, thus increasing its pressure from 45 pounds per square inch as above stated, to, possibly, 230 pounds per square inch. This increase of pressure is of course due to the expansion of the gas, caused by the heat of combustion. The piston is now forced to the end of the cylinder with great energy. This energy is largely taken up by the flywheel, F, which now continues to rotate, thus moving the piston back to the starting point.

By opening the exhaust valve, E, as the piston begins its retrograde movement, it will be seen that the burned gas, at present within the cylinder, will be forced out through the open valve, E, as shown in figure 4. When the piston has again returned to its original position (shown in figure 1) the exhaust valve, E, is allowed to close, and as the flywheel still continues to rapidly rotate, the whole series of operations, as above described, is again performed. Continued repetition of this cycle of operations causes the motor to keep on running when once started.

CHAPTER II.

Methods of Mixing Gasolene and Air.

We shall describe the various methods of mixing the gasolene and air, so as to form a combustible mixture for use in gasolene motors.

There are two distinct methods of obtaining the combustible mixture. The older and more generally used method is known as "vaporizing" the gasolene. We shall describe this process first. Later we shall deal with the other method which is known as "carburetting" the air. We consider this expression very indefinite and therefore will refer to the process as "atomizing" the gasolene, when we have occasion to describe it.

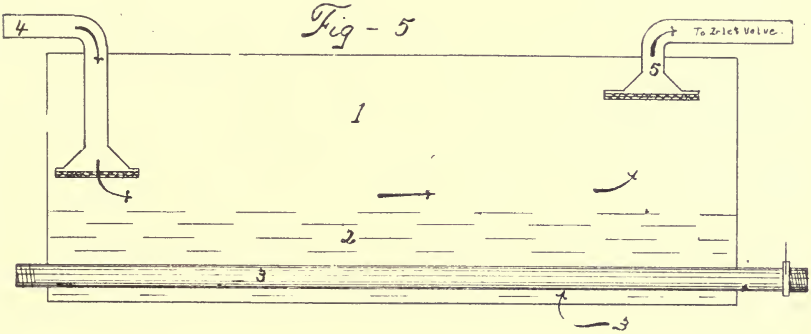
VAPORIZERS.

A vaporizer usually consists of a tank, 1, figure 5, partially filled with gasolene and having at one end an air supply pipe, 4, and at the other end a gas delivery pipe, 5, which is connected with the inlet valve, I, of the motor. (See figure 1). Through the lower part of the tank, 1, passes a pipe, 3, for the purpose of conducting heated water or air through the gasolene, 2. The following simple experiment will illustrate the action of a vaporizer.

If the reader will dip his hand in gasolene and upon withdrawing it will move it rapidly through the air, he will find that the gasolene almost instantly disappears, leaving his hand very cold. Let the reader imagine his hand within the tank, 1, in place of the gasolene, 2. Should air be now drawn into the tank, 1, through the air supply pipe, 4, it would pass over his hand and leave the tank through the gas delivery pipe, 5, and if his hand had been dipped in gasolene, as mentioned before, the liquid would vaporize, leaving his hand very cold, while the air passing through the delivery pipe, 5, would be charged with gasolene vapor, thus making a combustible gas. Should this experiment be continued the hand would finally freeze, provided it was kept moist with gasolene. While the hand continued to grow colder the vaporization would gradually be less, consequently the air passing through the tank, 1, would convey less gasolene vapor with it. Having outlined the principles of vaporization we will return to our description of figure 5.

As the air enters the tank, 1, at one end and leaves it at the other, thus passing over the whole surface of the gasolene within the tank, it is obvious that the air has every chance to take up as much of the vapor as possible, and this is the object sought. By heating this gasolene we aid the vaporization and that is the object of pipe, 3, (as before mentioned). In a small motor the heat from the exhaust may be allowed to pass through this pipe. In larger motors that

Fig - 5

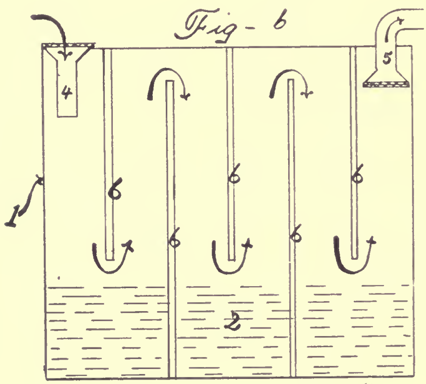


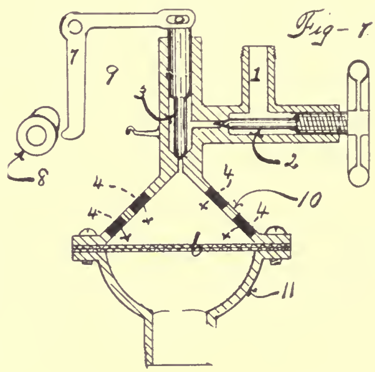
have water jackets the heated water, after circulating around the cylinders, may be forced through the pipes, 3, thus serving the double purpose of heating the gasolene and at the same time cooling the water. In either case it is better to have a valve, 3′, somewhere in the pipe so that the operator may have control of the amount of heat used in warming the gasolene, as it is desirable to keep an even temperature within the gasolene tank.

We have used the vaporizer shown in figure 6, with considerable success. We shall give scale drawings when we describe a complete outfit in detail, but at present it will suffice to show it diagramatically for the purpose of explaining that the absorbent partitions, 6, are used in order that there may be more vaporizing surface exposed to the passing air, thus reducing the size of the apparatus. In figure 6, the direction of the air is indicated by arrows. Each alternate partition has its lower edge immersed in the gasolene, which is fed up, not only by capillary attraction, but also by the continual shaking of the vehicle on the road, thus keeping the gasolene in motion and spraying it over the partitions.

ATOMIZERS OR CABURETTERS.

In the working of an atomizer for mixing liquid gasolene with air for an "Internal combustion motor," one in which the fuel is burned within the cylinder, we depart entirely from the principle of a vaporizer, and depend upon the minute sub-division of the gasolene by causing it to strike with force, some obstruction, thus spraying the liquid oil into the





rapidly moving air as it rushes through the supply pipe connected with the inlet valve, I, figure 1. When it is realized that in the modern high speed vehicle motor the air rushes through the inlet pipe at about 1 1-2 miles a minute it will be understood that any small quantities of gasolene carried by the air will be broken up into an infinite number of invisible particles by their rapid striking against the inlet valve, or obstructions purposely placed in their path. With the atomizer it is possible to measure the amount of gasolene that shall flow in for each given stroke, and to thus determine the richness (in gasolene) of the mixture. There is to some extent a vaporizing action when an atomizer is used, and this action can be considerably increased by heating the air before the gasolene is introduced, or by heating atomizer and all. This vaporizing action is slight when heat is not resorted to.

In figure 7, is shown a good serviceable atomizer. In this form the gasolene is allowed to drop into the inlet passage by the positive action of the factor, as will be presently described. In figure 8, is shown a still more simple form of atomizer in which no mechanically operated parts are necessary. In this instance the gasolene is automatically dropped into the inlet passage by a valve operated by the air pressure in its rush to fill the cylinder on the inlet or "suction" stroke.

Having now outlined the object of each design we will return to figure 7, and consider in detail its various parts and their functions. 1, is the gasolene supply pipe. 2, is the regulating valve for governing the quantity of gasolene that shall flow into the atomizer. 3, is the time valve which determines when the gasolene shall flow. It will be understood that if one valve has control only of the quantity of gasolene that shall flow into the cylinder, while the other valve determines when and for how long it shall flow, between the two we have almost unlimited control of the mixture. The regulating valve, 2, is operated by hand and should have a fine thread cut on its spindle so as to allow a reasonable degree of delicacy in adjustment. It is better to make the point of the valve, 2, of slight taper, as this will further add to accuracy of adjustment. 3, is a check valve only and may have a point of any shape. The sole purpose of this valve is to prohibit the flow of gasolene excepting at such times as the cam, 8, (driven by the motor) shall force it open against the spring by action of the lever, 7. The cam, 8, should be set so as to open the valve, 3, only during the inlet stroke of the piston. The hood, 10, is perforated to allow the passage of air as shown by dotted arrows, 4. Between the hood, 10, and the base piece, 11, there are several layers of fine wire gauze, 6. Through this gauze and pipe, 5, all the air must pass on its way to the cylinder, pipe, 5, being connected to inlet valve, I, figure 1. Having described the various parts of the atomizer it will now be in order to explain its action.

Suppose the suction stroke of the motor is about to take place. We first open the valve, 2, the proper amount (found by experience) when the passage, shown in white, will immediately fill with gasolene from pipe, 1, (which has previously been connected with the supply tank). The tank should be elevated about six inches above the atomizer, so as to give the gasolene a slight pressure. We now turn the fly-wheel, F, figure 1, as previously described, and as the suction begins air will rush through the holes, 4, in the hood of our atomizer just as cam, 8, begins to push against the bell crank lever, 7, which in its turn opens valve, 3, thus allowing gasolene to flow through as quickly as it can get past the regulating valve, 2. Because of the partial vacuum in our inlet pipe, 5, and in the chamber above it, the gasolene will spray against the gauze, 6, with considerable vigor. The gasolene is here met by the in-going air, and it will be very finely atomized by the time it has passed the wire gauze. The above series of operations continues as long as the inlet valve, I, figure 1, remains open. But just as the inlet valve closes, the cam, 8, figure 7, allows the spring, 9, to close the valve, 3, until the next inlet stroke takes place. The whole operation is then again repeated.

In figure 8, there is a slightly different action than in such atomizers as shown above, inasmuch as the time valve, 3, is operated by the in-coming air, instead of by a cam as in the previous instance.

FIGURE 8 CONSIDERED IN DETAIL.

1, is the supply pipe; 2, the regulating valve; 3, the time valve; 4, the inlet passage; 5, the outlet; 6, the wire gauze, and, 9, the spring holding the valve, 3, normally closed.

The radical difference between the atomizer shown in figure 8, and the one shown in figure 7, lies in the baffle plate, 7, of figure 8. This baffle plate serves the same purpose as the cam, 8, in figure 7. It will be observed that this baffle plate is of nearly the same diameter as the inside of our case, 10, and is rigidly attached to the stem of the valve, 3. It will be further noticed that the partition, 8, (which has air holes through it) carries a boss central with the case and in line with the seat of the valve, 3, and that in the boss fits the stem of this valve, which stem, as before mentioned, has the baffle plate, 7, rigidly attached thereto. It will also be noticed that the spring, 9, bearing against the under side of the plate, 7, tends to hold the valve, 3, closed. On referring to the drawing it will be further observed that when the baffle plate, 7, is drawn down (as indicated by dotted lines) the annular space between the periphery of the disc, 7, and the inside of the chamber, 10, will be enlarged because of the greater internal diameter of said chamber at this place.

ACTION OF ATOMIZER.

Suppose we open the regulating valve, 2, a proper amount and then turn the flywheel of our motor so as to draw the piston out of the suction stroke, we will notice that the disc,

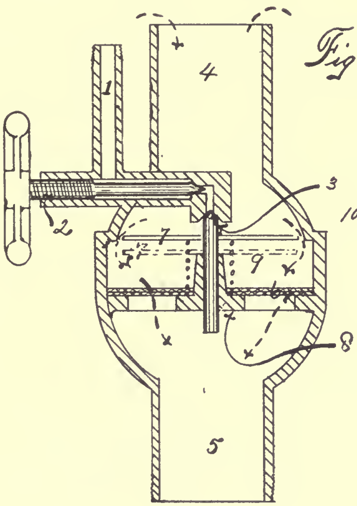


Fig-8.

7, will not allow enough air to pass around it, in its present position, to supply the cylinder. The result will be that the in-rushing air will force this baffle plate downward, to the position shown by the dotted lines, figure 8, and in so doing will open the valve, 3, thus allowing the gasolene to flow over the disc, 7, in a very thin film. At the same time the in-rushing air will spray the gasolene over the edge of the disc, 7, and through the several layers of gauze, 6, in this way evenly distributing it throughout the whole volume of air, thus forming a very equal and highly combustible gaseous mixture.

ADVANTAGES AND DISADVANTAGES OF VAPORIZERS AND ATOMIZERS.

At all times in vaporizers there is a space above the liquid gasolene that is filled with a combustible gas. This gas may be the result of the natural evaporation of the gasolene, or it may be a reserve left in the tank from the previous run of the engine, or it may result from a combination of these causes. Commercial gasolene is really a combination of several oils of varying density, and it is evident that the more readily evaporated components will pass off first, leaving the heavier and therefore less volatile oils in the tank, and this fact leads to probably the most serious objection to a vaporizer. If the tank has been recently filled the reserve gas we refer to will be very useful in starting the engine. It will be very rich and usually of sufficient quantity to keep the engine up to speed until the vaporizer has warmed up, and is in good working order. But on the other hand if the gasolene has been in the tank for a considerable length of time the lighter oils will have evaporated and it will be found difficult to start the engine. In such cases it is customary to refill the tank with fresh gasolene after pouring out the gasolene that has become impoverished by evaporation. This heavy oil may be used for cleaning, etc.

The element of danger is not removed by the use of the vaporizer, but if all the openings to the air are covered with several layers of fine wire gauze this danger is reduced to a minimum. This precaution does not, however, make the reserve gas within the vaporizer less inflammable.

Moisture in the atmosphere frequently leads to trouble when vaporizers are employed. It is generally known that the atmosphere contains more or less water at all times when the temperature is above the freezing point (32 deg. Fahrenheit.) Usually the warmer the day the more water vapor there is suspended in the air. This is especially noticeable on very humid or "muggy" days. As we have previously shown, evaporation requires heat, and consequently evaporation causes our vaporizer to become cold, unless heated as we have before described. Suppose we do heat our tank but not enough to bring the temperature within it as high as the temperature of the surrounding air. The result will be that as the air is drawn over the surface of the gasolene it will become chilled and will then throw down some of its moisture because warm air will support more water vapor than cold air. This operation continued will interfere materially with the action of our apparatus. To obtain the best results it will be found necessary to keep the temperature of the vaporizer slightly higher than that of the surrounding air, or better still—dry the air. At this time we cannot go into this latter method of getting out of the difficulty, but ways will suggest themselves to the experimenter. In heating the vaporizer care should be taken that its temperature never gets much higher than that of the outside air, or else, in summer, much gasolene will be wasted by evaporation through the air-holes in the tank.

ATOMIZERS.

When used with larger sizes of motors (e. g., cylinders of 3 1-2-inch bore by 4-inch stroke and upwards) these give practically no trouble because the inlet stroke causes a strong suction or in-rush of air, that readily atomizes the gasolene, but when used with the smaller motors the atomizers must be properly designed and nicely made in order to get the best results. If these precautions are observed the experimenter will find great satisfaction in the use of atomizers for all classes of work. Atomizers have a great advantage over vaporizers because they use the liquid gasolene, and as the jolting of the motor vehicle over the roads keeps all the gasolene in the supply tank thoroughly stirred up—thus preventing any settlement of the heavier oils—it will be seen that the motor is working under uniform fuel conditions, whether the tank be full or nearly empty. In atomizers the gasolene is mechanically distributed throughout the whole body of ingoing air and consequently atmospheric conditions make but little difference to their action. This fact gives the atomizer a distinct advantage over the vaporizer. There is always considerable noise about an atomizer, especially those of the baffle plate pattern, and, of course, this is an objectionable feature. The piping from the gasolene tank to the atomizer may give trouble owing to loose or possibly broken joints, caused by the vibration. For this reason as little piping as necessary should be used and the atomizer should be placed near the inlet valve of the motor.

SUMMARY.

Vaporizers.

ADVANTAGES—Deliver the fuel to the motor as a true gas; usually make it easy to start small motors; have no moving parts, are therefore noiseless; deliver the gasolene as a gas, hence there is little leakage.

DISADVANTAGES—Are more or less dangerous; work under constantly varying conditions; usually waste considerable gasolene; are large and heavy and unsightly.

Atomizers.

ADVANTAGES—Always work under practically the same conditions; atmospheric conditions but little affect their operation; are light, neat and get-at-able; they do not require heating.

DISADVANTAGES—Are somewhat noisy; the pipes conveying the gasolene are liable to give trouble; they deliver the fuel to the motor as a mechanical mixture, not as a true gas.

CHAPTER III.

Hints about Combustion.

A substance burns because of three things. In the first place oxygen must be present. In the second place the substance must be combustible. In the third place the burning of the first particles must produce heat enough to ignite the adjacent particles, which in turn will ignite those next to them. This process will continue as long as the above named requisites are present, but the combustion will stop when any of the conditions fail. In considering the essentials separately we have first:

OXYGEN—Oxygen is one of the few chemical elements. As is well known, it is a gas that forms the life-sustaining property of the air, but it only forms a small part—about 1-5 —of the bulk of the air. The chief component of air is nitrogen, this being an inert gas, as far as we are concerned. Whenever the cylinder of a gasolene motor is filled with a mixture of air and gasolene, it will contain about four times as much useless—as far as combustion goes—gas—nitrogen— as it does active oxygen and gasolene vapor. This large proportion of nitrogen plays a very useful part, however, for it dilutes the mixture and thus causes the combustion to take place slowly. The spent gases left in the cylinder at the end of the exhaust stroke possess the same valuable attributes.

If the cylinder of an internal combustion motor were filled with a mixture of gasolene vapor and pure oxygen the heat generated after ignition would be excessive, and the expansion of the gas would be so sudden as to be practically an explosion. Ordinarily the mixture does not explode, although the non-technical journals frequently refer to the expansion as an "explosion" and to an internal combustion motor as an "explosive engine."

COMBUSTIBLES—Practically all the solids and gases known are combustible, but none of the liquids are. In considering the metals, such as iron, copper, tin, etc., as well as many of the rock formations and even diamonds, we must admit that under favorable conditions they are combustible. It will be observed that a wide range of substances come under this head, although we are at present concerned in only the combustible vapors derived from the various mineral oils. All such vapors are combustible when intimately mixed with air, usually in the proportion of about nine parts of air to one part of oil vapor.

PROPAGATION OF FLAME—As we have previously observed it is necessary that a burning substance by its combustion should generate heat enough to ignite the adjacent particles. Combustion will stop if this condition is not fulfilled. For instance, if a lighted match is placed under a piece of coal the match will hardly generate heat enough to fire the coal, but if we use the match to light a sufficient amount of more combustible material, such as wood chips, and then place the coal over the latter they will—after sufficiently heating the coal—cause the coals to ignite. If the flame is now fed with a constant draft of air, as in an ordinary stove, it will burn all the combustible material in the coal, leaving only the refuse product. Had we placed the burning coal where it was not subjected to the draft of the air the fire would have gradually gone out because enough heat would not have been generated to ignite the adjacent particles of the coal.

Let us consider another case. Suppose we strike a match out of doors when the wind is blowing. The match will usually go out because the cooling effect of the wind reduces the temperature of the flame of the burning match to such a degree that the flame fails to ignite the particles of adjacent wood. From the examples cited we may draw the following conclusion. Given a combustible material and plenty of oxygen to sustain combustion, it is still necessary to keep the burning substance so protected that it cannot become chilled below its ignition point, or it will stop burning. It will also be observed that although anthracite coal may require very favorable conditions to sustain combustion, there are more inflammable materials, such as gases, that will continue to burn under adverse conditions, because the heat generated by their combustion is greatly in excess of the amount necessary.

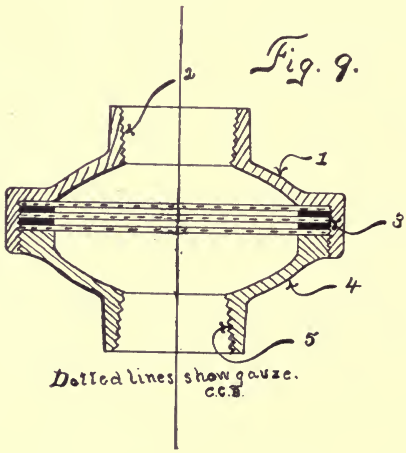
In the year 1815 Sir Humphrey Davy, the eminent English chemist, began a series of experiments by which he finally discovered the principles of burning gases while trying to find a way to prevent the explosions of fire damp in coal mines. These explosions were of frequent occurrence at that time. It is evident that if the presence of fire damp rendered the air within a mine explosive, it would be necessary to remove all chances of ignition taking place, because neither the gas nor the air could be driven from the mine. The only alternative was to isolate the miners' lamps, or other sources of combustion, from the enveloping inflammable atmosphere, in such a way that the flame from the lamp wick could not be mixed with the surrounding air. Understanding the principles of combustion, Sir Humphrey found by experiment that a flame could not spread through small tubes because the cooling effect of the walls of the tubes reduced the temperature to such a degree as to extinguish the flame. After making this step he made a complete lamp in such a way that the air in entering the lamp and the exhaust gases in leaving it must pass through small tubes. The lamp was entirely successful. If a miner entered a part of a mine charged with inflammable gas, and this gas passed through the tubes to the lamp it would burn within the lamp, but the flame could not strike back into the mine because it would be extinguished, just as the wind extinguished the flame of the match in our experiment.

After making a successful lamp on the lines mentioned, the eminent chemist shortened the tubes successively until they were finally so short that they resembled wire gauze. He then determined to try wire gauze, which he did with success. Miners' lamps have ever since been made on the same principles as Davy discovered, and the same principles are observed when wire gauze is used in connection with vaporizers for gasolene motors.

If a vaporizer is used, wire gauze must be always placed between it and the motor. If an atomizer is used, the wire gauze may not be essential, although it is always better to employ it.

One thickness of gauze may be sufficient but it should have at least 28 wires to the inch, or 784 meshes (28x28) to the square inch. It is safer to use several pieces of a finer gauze. We should advise the use of three layers, each layer to be separated from its neighbor by a ring washer about 1-16-inch thickness, and gauze of about 30 meshes to the inch. We have frequently used gauze of 40 wires to the inch, so the reader will observe that the only requisite is to have it

Fig. 9.



closely enough woven. The gauze will, to some extent, hinder the free passage of the air so the pipe should be enlarged at the place where the gauze is inserted. Of course if the air supply pipe is blocked by the gauze the engine will not give full power.

A good way to make up a handy fixture for retaining the gauze is shown in the accompanying sketch, figure 9. 1, is a dome-shaped casting threaded at, 2, to accommodate the motor fittings. This casting is threaded between the dome piece and the base piece, 4, which is threaded at , 5, to take the supply pipe fittings. The wire gauze discs with the ring washers between are placed in the recess between the dome piece and the base casting and the whole apparatus is then screwed up. By following these instructions the novice will have a reliable flame extinguisher and such a device should always be employed, care being taken that it is placed in such a position that it can never get red hot, because if it should it would not prevent the flame from striking back.

Such a device as we have described will be found generally useful about the shop and may be used whenever experimenting with oil engines. It is best to make this apparatus with standard pipe fittings, uniform with those used with the different motors that may be on hand, and it can be then used in connection with any of them without being changed. It should be always placed as near as possible to the inlet valve of the motor.

CHAPTER IV.

Means of Ignition.

Before describing any of the practical methods we might employ to ignite the gas mixture within the cylinder of our motor, let us clearly understand that the factor of time plays a very important part in this connection. The mixture must be fired at the right instant to insure the best results from our motor. If the charge in the cylinder "exploded" in the literal sense of that word it would be easy to regulate the time of ignition, but an explosion (in the true sense of the word) does not take place. The gas within the cylinder is burned just as a piece of paper or any other combustible substance is burned.

Suppose we take a piece of newspaper, twist it up into a tight roll, and then light one end of it. It is hardly necessary to say that the paper will burn slowly. Now let us take a similar piece of newspaper and tear it into narrow strips, lay them closely together and then light them. In this instance the paper will burn much more quickly than in the previous experiment, and the more air spaces there are between the strips of paper the more quickly will the paper burn. Now the gas in the cylinder of the motor burns exactly as does the paper; the only difference being that in one case a solid is burning and in the other case a gas is burning. And being a gas it can be more readily mixed with the air than can the strips of paper, and consequently the gas burns much quicker. At the instant of ignition the gas begins to burn, and the flame travels through the mixture, from the point of ignition to the remote parts of the combustion chamber of the motor, just as the flame traveled along the paper strips, only much more quickly.

We wish to impress upon the minds of our readers that it takes "time" for the combustion, in the cylinder of an internal combustion motor, to take place. It is the realization of this fact that has made it possible for certain designers of small motors to build the modern high speed engines. Had they retained the old-fashioned notions of instantaneous combustion they would be yet building the old-fashioned slow speed engines. It will be observed that if the piston speed is slow in comparison to the speed with which the flame is propagated in the cylinder, the time of ignition (in its relation to the stroke) is of little importance. If the piston speed is high, as it should be for economical working, the time of ignition is then of primary importance.

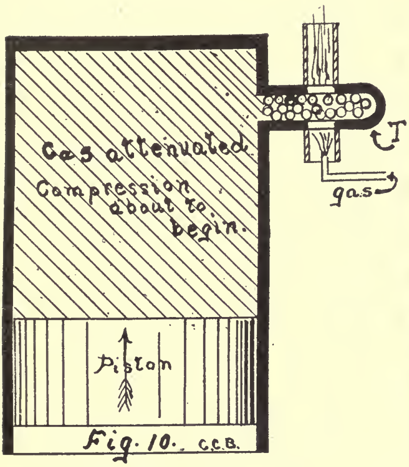


Fig. 10.

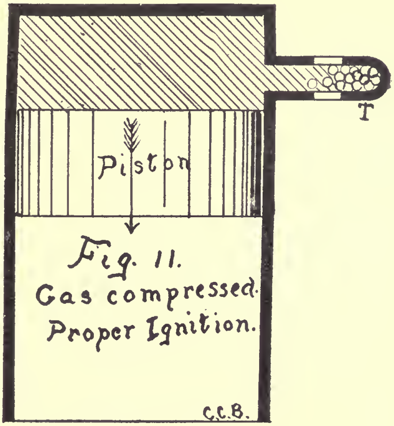


Fig. 11.

There are two successfully developed methods of igniting the gasolene mixture within the cylinder. One method of ignition is by means of a hot tube, the other method is by means of an electric spark.

We shall consider these two methods in the order named, and will show by diagrams how the theories advanced may be taken advantage of in practice.

THE HOT TUBE—In 1879, the well-known gasolene engine inventor, Mr. Atkinson, first used the hot tube to ignite the charge, and his method is still followed, although slight modifications have of course been made. This arrangement consists of a tube, T, figures 10, 11, 12 and 13, the inner end of which is screwed into the cylinder wall, so as to be in direct communication with the compression space, and the outer end is sealed. A gasolene burner, similar to a plumber's ordinary torch, is placed below the tube, and the torch flame is directed against the tube, which is kept heated to a bright cherry red when the motor is running. The torch is usually surrounded by a chimney, as shown in figure 10, for the following reasons. It increases the draught and thus makes the flame burn better; it confines the heat of the flame and directs it to a spot where it will do the most good and it prevents draughts of air from extinguishing the flame.

Let us consider our figures in detail. Figure 10, shows the motor cylinder full of a combustible gas, the piston being

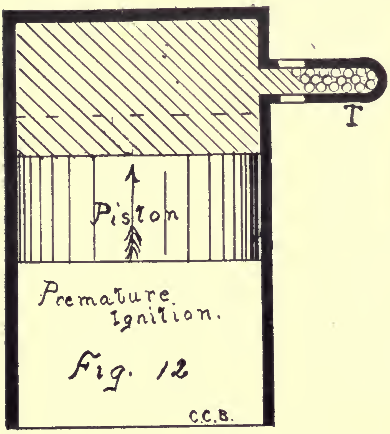


Fig. 12

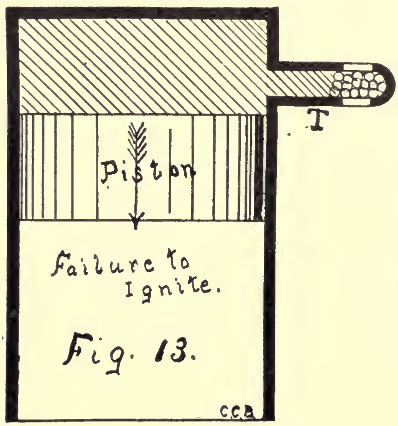


Fig. 13.

at the end of its outward stroke and the compression stroke about to begin. The tube, T, not having any outlet at its free end, it is obvious that it is now filled with burned gas that has remained within it since last ignition. This burned gas is not combustible, and although the tube is hot it cannot fire the combustible gas now in the cylinder until a portion of that gas is forced into the tube on the inward or compression stroke of the piston. In order to illustrate this action clearly we have not shaded the heated part of the tube, which we show in section, but have cross-hatched the combustible gas, and we have represented the burned inert gas by a series of small circles.

Suppose the piston, figure 10, is beginning the inward stroke. It is evident that as the gas is compressed behind the piston it will force the inert gas within the tube toward its closed end, thus allowing the active charge to reach the heated part of the tube, as shown in figure 11. It is necessary that this fresh gas should reach the hot part of the tube not before the compression is completed, but just as the piston is about to return on its outward or working stroke.

If the tube is heated at a point too near the cylinder the gas within it will be fired before the compression stroke is completed, see figure 12. This condition will cause the piston to start backward. If the tube is heated at a point too remote from the cylinder, figure 13, the gas will not ignite. This condition will prevent the motor from starting. The time of ignition is a most important factor in the proper running of any gasolene motor, and it should depend upon the speed of the motor. If ignition takes place on the "dead center" when the crank is being slowly turned, it is evident that the maximum pressure could not occur until the piston was perhaps half way out on the working stroke if the engine were running at a high speed. Because of this fact it should be possible to heat the tube nearer the cylinder, as the motor runs faster, so that the greatest pressure will occur when the crank has passed just over the dead center, and the motor will be then working under the best conditions.

The method of regulating the time of hot tube ignition by heating the tube at different points along its length, as above described, is not the only one that may be used. A valve may be placed in the passage between the tube and the combustion chamber of the motor. Normally this valve is closed, but when ignition shall occur it is opened, thus allowing the gas to communicate with the hot part of the tube. This "time valve" is operated by the motor, and numerous ways will suggest themselves to the student by which it may be accomplished so as to give the proper "lead" according to the speed of the motor. In our opinion it is necessary to employ a time valve when hot tube ignition is used in connection with a variable speed motor. This opinion is the result of much experimenting.

We shall not go into the details of our arrangement at present because we believe that any method of ignition that depends upon a torch to supply the necessary heat is not only dangerous, but for other reasons unsuitable for motor vehicle motors. We strongly advise our readers to master the subject of electrical ignition.

NUMEROUS FAILINGS OF THE HOT TUBE IGNITION.

In the first place the necessary torch has a naked flame of considerable size that must be more or less exposed. Should a collision or other accident result in the vehicle overturning, or should the gasolene connections become broken, the carriage might be destroyed by fire. In order that the torch may properly work, its gasolene supply must be under air pressure of fifteen or twenty pounds to the square inch. Now all air pressure devices in connection with gasolene supply should be avoided because the supply pipe, or a union or other fixture might break, or open a leak, as a result of vibration or a shock, when the gasolene would spurt from the rupture with considerable force, thus filling the atmosphere with a highly inflammable gas which is liable to ignite from the flame of the torch. Light steam carriages possess this same defect. Air pressure devices give further trouble because the tank holding the gasolene supply must be air tight. The air must be compressed above the gasolene by means of an air pump. This means complication of equipment, and sometimes a source of trouble. As gasolene is drawn from the tank the air pressure falls; as the temperature of the surrounding air varies the gasolene within vaporizes more or less, and the air pressure as again affected. These variations affect the working of the torch, the working of the torch affects the heat of the tube, and variations in temperature of the tube cause the motor to run irregularly. The torch which heats the tube consumes about half as much gasolene as does the motor, and the considerable heat generated is near the cylinder, because the hot tube is short, and we are thus heating a part of the motor that we are also water-jacketing to keep cool. The torch flame may be extinguished by the wind, and the constant draughts to which it is exposed vary the working of the burner; and again the burner may clog, as burners do at times, because the heat corrodes the small aperture through which the gasolene vapor is forced from the supply tank, and because of the rusting of the needle valve. The stuffing box around the spindle of the valve of the torch causes frequent trouble because it is very difficult to make it hold against gasolene under pressure, for more than a day or two. It requires about fifteen minutes time to properly heat the ignition tube before the motor can be started, and that is a disadvantage.

Hot tube ignition has the almost single advantage of being generally understood, because the torch is the same as a brazier's torch, and bicycle repair men understand it.

The writer spent half a year experimenting with different hot tube ignition devices, and finally abandoned them because the uncertainty and danger involved was more than the single virtue of simplicity could equalize.

CHAPTER V.

Electric Ignition.

METHODS OF ELECTRIC IGNITION.

We may say right here that the electric method of ignition is the most satisfactory way of igniting the gas mixture in the cylinder of an internal combustion motor. The novice may at first consider the necessary apparatus of a complicated nature, and somewhat delicate in construction, but if he will take time to thoroughly master the operation of the parts involved, he will find the subject more simple than he at first supposed.

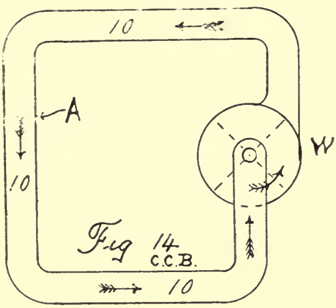
There are two distinct methods of electric ignition. We shall first consider the "low pressure" system, in which the spark is spoken of as a "wipe spark," a "primary spark," a "kiss spark," or a "make and break spark." Later we shall consider the "high pressure" system, in which ignition is effected by a "static spark," a "jump spark" or a "secondary spark."

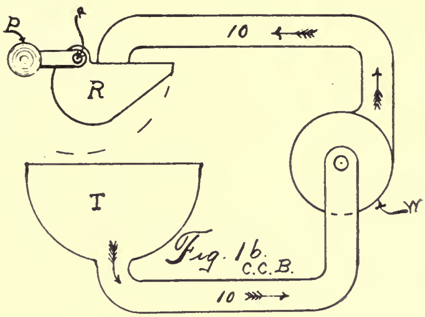
At present we shall simplify the matter by referring to the low pressure system of ignition as effected by a primary spark, and we shall refer to the high pressure system of ignition as effected by a secondary spark.

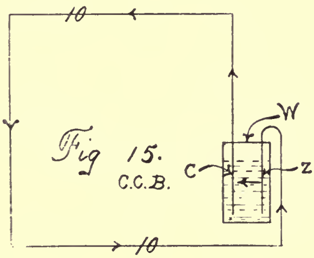
In order to clearly describe the difference in action of electricity at high pressure and of electricity of low pressure we shall substitute hydraulic circuits for the different electrical circuits, and by analogy, endeavor to illustrate the theories of the flow of the electric current.

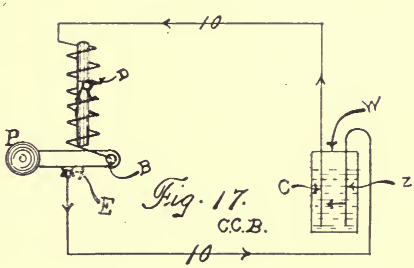
THE PRIMARY SPARK.

If the reader will refer to figure 14, he will see illustrated an hydraulic system consisting of a centrifugal pump, W, and an endless pipe, 10, connecting the outlet of the pump with its own inlet. Suppose we fill this pipe and the pump casing with water, and revolve the wheel, W, in the direction indicated by the arrow. It is evident to the reader that the water will circulate in the direction of the arrow, beginning at the outlet of the pump, and flow through the pipe system, 10, to the wheel inlet, at (or near) its center. It will be further observed that it requires power to drive the wheel, W, and that this power has no effect on the water further than to cause it to circulate through the endless pipe. Let us now refer to a corresponding electric circuit shown in figure 15.









In this figure we substitute the wire, 10, and the cell, W, for the pipe, 10, and the pump, W, of figure 14. It is understood that the cell, W, in figure 15, may be an ordinary primary electric cell such as is used for general electrical work, and frequently erroneously called a "battery." In this cell the plate, Z, is of zinc, and the plate, C, is of carbon, and the cell is nearly filled with some chemical agent that will decompose the zinc but will have little effect on the carbon. It will be observed that we have lettered the cell, W, in one case and the pump, W, in the preceding figure. This is done because the letter, W, always stands for work. The work in one case is the amount of chemical energy absorbed by the consumption of the zinc, and in the hydraulic analogy it represents the amount of mechanical energy necessary to revolve the pump. To return to our cell; we must remember that it is the chemical action therein that generates the electrical pressure that causes the circulation of the electric fluid through the wire, 10, figure 15. The arrow indicates the direction of the circulation of the electric fluid. It will be noticed that the circulation starts from the zinc plate, Z, and passes through the contents of the cell to the carbon plate, C, through the wire, 10, back to the zinc, Z. It may be well to mention that the terminal of the carbon plate is known as the "positive pole" of the cell, usually shown by the sign +. The terminal of the zinc plate is known as the negative pole, and is indicated by the sign —. The student would do well to memorize these signs.

Let us now return to our diagrams. Right here we want to point out the following facts. If the pipe, 10, figure 14, should be broken at A, the circulation of water would cease, after the slight amount of water above the pump was discharged, although the pump might be kept running and more or less work thus done. On the other hand if the electric circuit, figure 15, be broken at any point the flow of electricity would cease, as did the flow of water in the previous instance, but when the wire broke the rupture would be indicated by a small spark, whereas we have already noted that the breaking of the pipe would result in a discharge of water. We may carry our analogy further by showing that the consumption of zinc would not stop on the breaking of the wire, 10, no more than did the pump stop revolving when the pipe broke as before described. However, the amount of work done by the consumption of zinc is a great deal less when the circuit is broken than when it is complete, just as the work done by revolving the pump, W, figure 14, would be less after the pipe, 10, was broken, than when it was forcing the water through the pipe system.

Our object in going into the above detail is to show that there is a gradual deterioration in all electric cells whether they are in use or not, but that when they are in use the decay resulting from the work done is much greater. Another point we would mention is that whenever the electric circuit is completed a rapid consumption of zinc takes place within the cell, and that every spark made transforms just so much useful energy. These points will be valuable to the amateur who lets his cells stand with the circuit complete and to his sorrow finds, when next wishing to use them, that they have become discharged because of his negligence.

SPARK COILS.

There is a means to increase the size of the electric spark without adding cells to the circuit, although the drain upon the cells used is greater by following this course. Let us refer to the hydraulic system shown in figure 16, which we hope will help the reader to grasp the theory of the spark coil, which is used to obtain an accumulated discharge of electricity when the circuit is broken. In figure 16, we have the pipe system, 10, and the pump, W, just as we had in figure 14, excepting that in the figure we are about to consider we have placed in the pipe system a reservoir, R, and a tank, T. It will be noticed that the reservoir is pivoted at, r, and that it is counterbalanced by a weight, P. Suppose we fill the tank, T, and the lower pipe, 10, with water and then rotate the pump, W. It is evident that, no matter how much we rotate the pump, the reservoir, R, can only hold just so much and that any further supply of water will overflow into the tank, T, also that the amount of water held within the reservoir, R, will depend upon its size. Suppose that after the pump, W, has rotated a few times and the reservoir is nearly filled with water, we quickly raise the weight, P, into a vertical position. The water contained in the reservoir, R, will suddenly flow into the tank, T, from where it will be again pumped into the reservoir after the reservoir is allowed to assume its original position. It is evident that as the pump in this diagram rotates at the same speed as the one shown in figure 14, and in addition is supplied with the reservoir, R, that we may by means of this mechanism get an interrupted discharge into the tank, T, of much greater volume than would be the continuous discharge from the pipe, 10.

We may now consider figure 17. In this figure we have our electric cell, W, which furnishes the energy in place of the pump, W, of figure 16, and we have as before the circuit, 10, reservoir, R, and discharge lever, P, all arranged as before. The essential difference is in adapting the reservoir, R, and discharge lever, P, to the electric circuit that we will now describe, in place of the previously considered hydraulic circuit. The reservoir in figure 17, is nothing more or less than a large electro magnet known technically as a spark coil. It consists of several helixes of insulated copper wire, D, wound on a form in the same way that thread is usually wound on a spool. Through the center of the coil of wire is placed a

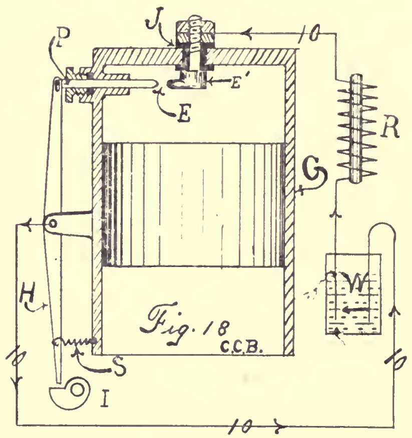


Fig. 18

soft iron bar, or better still, a group of soft iron wires. The discharge lever, P, is shown arranged similarly to the one shown in figure 16, in order to make the analogy more complete. It comprises a lever pivoted at, B, weighted at, P, and in contact with the wire, 10, at E. We will now follow out our circuit as we did that shown in figure 15. Beginning with the zinc plate, Z, the current flows, as before, first to the carbon plate, C, then to the wire, 10, by which it is conveyed to our reservoir or spark coil, R, and then to the lever, P, through the contact points, E, back to its starting point, Z. As in the case of the reservoir of water, R, figure 16, our spark coil will accumulate an amount of electricity only in proportion to its size, and when the contact points, E, are separated by raising the lever, P, we get a much larger interrupted discharge than we did when the contact was similarly broken when no spark coil was used, as in diagram shown in figure 15. It will be understood that the lever, P, and the spark points, E, figure 17, must be located within the cylinder of the motor. In which case the lever, P, must be so arranged that it can be operated from the outside, and of course this involves the use of a gland or some form of stuffing box. One method of applying this apparatus is shown graphically in figure 18, in which, C, is the motor cylinder containing the sparking points, E, while the discharge lever is shown at, P, the actuating lever at, H, the spark coil at, R, the cells at,

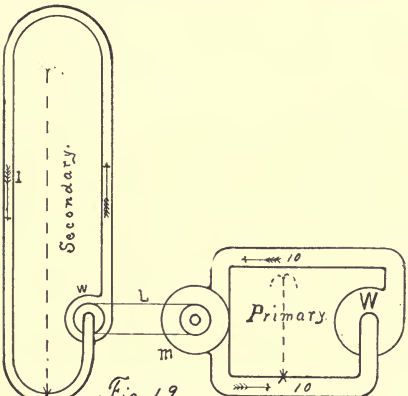


Fig. 19. C.C.B

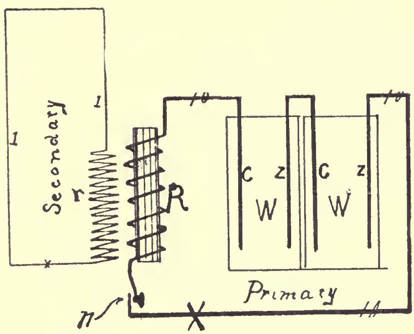


Fig. 20. C.C.B

W, and the circuit at, 10. In this diagram we show a simple method of separating the spark points, E, by means of the actuating lever, H, a cam, I, and a spring, S. It is necessary to mention that the sparking point, E′, must be insulated from the cylinder of the motor by means of some non-conducting material as shown at, J.

When we come to the actual construction of our motor we shall go into all the details of ignition, giving complete working drawings of all the motor parts and accessories, including a good serviceable electric sparking mechanism, so that the amateur can build his vehicle complete in all its parts. All information furnished will be the result of actual experience and work-shop practice.

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THE SECONDARY SPARK.

On referring to figure 19, the reader will observe a diagram of an hydraulic system, somewhat similar to the one already illustrated, in which, W, is a pump; 10 is a pipe circuit leading from the outlet of the pump, W, to its own inlet. It will be noted that this pipe system includes a water wheel, M, so placed that the water flowing through the pipe, 10, will strike on some of the blades of the water wheel, M, in such a manner as to cause it to rotate at substantially the same speed that the pump, W, is driven. Belted to the water wheel, M, is a second pump, w, of much smaller size than is the main pump. The small pump, w, is also contained within an hydraulic circuit, 1. The area of the pipe in this secondary circuit is supposed to be 1-10 as great as the area of the pipe of the primary circuit, 10. But the height to which the water is lifted in the secondary circuit is supposed to be ten times the height to which it is lifted in the primary circuit by the main pump, W. If ten gallons of water are lifted a distance of one foot in one minute by the main pump, W, it is evident that the work done is equivalent to the performance of the smaller pump, w, in lifting one gallon of water a distance of ten feet in one minute. It will, of course, be understood that we are not considering frictional and other losses in our apparatus.

Let us refer to figure 20. In this diagram we have a primary circuit illustrated, somewhat like the one previously shown, in which, W, is a cell and, 10, is the circuit. This circuit, it will be observed, includes a coil, R, which is similar to the spark coil referred to in last week's paper. This primary circuit includes also a make and break device, X, for interrupting the flow of the electric current.

The secondary circuit consists of a continuous wire, 1, supposed to be 1-10 in area of the wire, 10. This secondary circuit is continuous, although it includes the coil, r. The coil, r, is supposed to contain ten times the number of coils of wire than does the coil, R. Thus the secondary circuit is 1-10 as large as is the primary circuit, although it is ten times longer, and thus the proportions are identical with the proportions of the hydraulic system shown in figure 19.

It will be remembered that in our secondary hydraulic circuit that we had a bulk of water, 1, under pressure, 10, whereas in our primary circuit we had a bulk of water, 10, under pressure, 1. But the product of the bulk (the quantity) times the pressure was the same in each case. In the secondary hydraulic circuit we obtained the pressure by driving a small pump, w, from a water wheel, M, that was fed by a large body of water at low pressure that passed through the pipe, 10. We wish the reader to observe that we obtain the same result in the electric circuit. We have the primary (or quantity) circuit, 10, through which passes a large quantity of electricity that operates the coil.

For convenience, it will be well to consider the water wheel, M, of our primary circuit, and the pump, w, of the secondary circuit, together with the belt, L, as a transformer. Because the apparatus, as a whole, transforms the low pressure of our primary circuit into the high pressure of the secondary circuit, inversely as the quantity of water is reduced. In figure 20, the coils, R, and, r, also form a transformer whose action on the electric fluid is similar to the action of the hydraulic transformer (the pump and wheel) on the water. That is, the large quantity of electricity flowing through the circuit, 10, and through the coil, R, at low pressure, is transformed into the small quantity of electricity, at proportionately greater pressure, that is in the coil, r, and the circuit, 1. The electric pressure in the secondary circuit will be greater than the pressure in the primary circuit as many times as the number of coils in, r, is greater than the number of coils in, R. The quantity of electricity will be inversely transformed.

To still further consider our hydraulic analogy. If a small hole were drilled in pipe 10 of the primary circuit at, X, figure 19, the water, being at low pressure within the pipe, would spurt from this hole to a height, say, indicated by the dotted line in the figure. Should a hole be drilled in the pipe of our secondary circuit at, x, the water would spurt much higher than it did in the previous instance, because there is a much greater pressure in the pipe of the secondary circuit. In other words, the distance the water would spurt would indicate (in each case) the relative pressure within each circuit.

In the electric circuit, figure 20, should we break our primary electric circuit, 10, at, X, a short but thick spark would result. Should we break the secondary electric circuit, 1, at, x, a long, but very thin, spark would result. The length, then, of the spark would indicate in each case, the relative pressure within each circuit.

In our hydraulic circuit, figure 19, it will be evident that: On account of the low pressure in the primary circuit, 10, thin pipes will withstand the strain. In the secondary hydraulic circuit stronger pipes will be required to withstand the greater pressure.

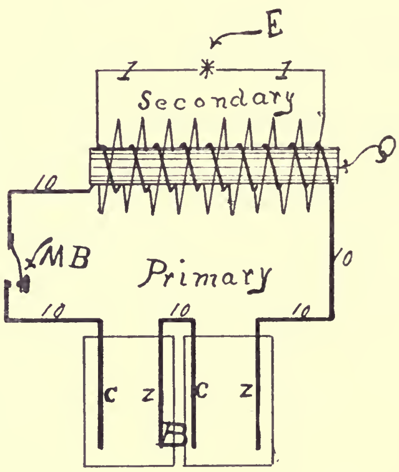


Fig. 21.
C.C.B.

The same statements apply to the electric circuits shown in figure 20. In the secondary circuit, 1, great care is necessary in properly insulating the wires and other parts because leakage is very likely to occur, owing to the great pressure of the current. In the case of the primary electric circuit, 10, figure 20, extraordinary precautions are unnecessary because the current is at low pressure.

Having considered the hydraulic analogy as long as it will apply to the electric circuit, we propose to now generally describe the several parts that may comprise the transformer, R, r, and in the future we shall refer to the transformer by its technical name of a Ruhmkorff coil.

In figure 21, we have a diagramatical representation of a Ruhmkorff coil in which, Q, is supposed to be a bundle of soft iron wires about 1-2 inch in diameter and six inches long. Around this bundle of soft iron wires, technically known as the core, is wound a continuous insulated copper wire, 10, of about 14 gauge. The two ends of this wire are carried around to the make and break key, M-B. Around the outside of primary coil, 10, is wound another coil of wire, 1, which is of much smaller size, usually about 36 gauge. This secondary coil must be very carefully insulated from the primary coil over which it is wound. Between the free ends of the secondary coil the spark takes place when the apparatus is in use.

In an ordinary coil, such as we refer to in this chapter, used to ignite the charge in a gasoline motor, the primary coil, 10, is only a few yards in length, whereas the secondary coil of wire, 1, is usually three-quarters of a mile to one mile long. It may interest our readers to know that very powerful coils for experimental purposes have been constructed which have contained as much as 380 miles of wire in the secondary circuit. A coil of this size has given a tremendous jump spark 14 inches in length.

The working of a Ruhmkorff coil depends upon the breaking of the primary circuit, 10, and although the secondary circuit, 1, has no connection with the primary circuit, there will be a spark between the ends of the secondary wire at, E, provided the ends are sufficiently near, say about 1-8 inch space between them. A spark will be made at every break of the primary circuit by the make and break device, M-B. There will be no spark at, E, when the primary circuit is completed. The spark occurs at, E, only when the primary circuit is interrupted. The make and break device, M-B, generally known as the "trembler" or "vibrator," may be operated by the motor, as shown in figure 22, in which, C, is the Ruhmkorff coil. 1, is the secondary circuit, 10, is the primary circuit including a battery of cells, b, and the vibrator. The vibrator consists of a cam, A, the finger, F, which is supported by a spring on the stud, S, in such a manner as to make contact with the regulating screw, R, when the finger, F, is forced against the screw by the cam, A.

It will be observed in the drawing that one end of the primary wire, 10, is connected to the stud, S, while the other end is connected to the regulating screw, R. Therefore, when the cam, A, presses the finger, F, against the regulating screw, R, the circuit will be complete, permitting a flow of electricity from the battery, B, through the coil, C, and wire, 10, stud, S, finger, F, regulating screw, R, and by the remainder of wire, 10, back to the battery, B. As the cam is rotated in the direction shown by the arrow it will come into the position shown. The finger, F, will then drop into

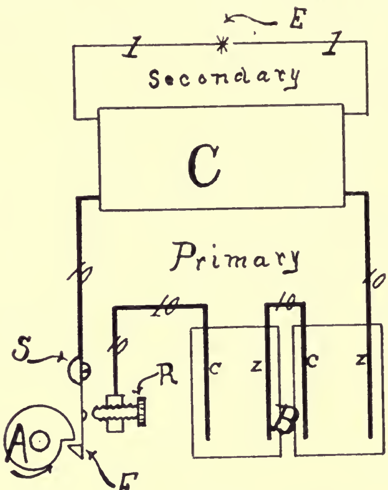


Fig. 22.
C.C.B.

the hollow of the cam, A, by its own elasticity, thus breaking the circuit between itself and the regulating screw, R, when a spark will occur at, E. This system of making a secondary spark by means of a mechanically operated make and break device was probably first used in connection with gasoline motors by DeDion et Bouton, of Puteaux, France, and has since been almost universally copied.

In figure 23, we show how the make and break device is operated automatically. If the reader will refer to figure 21, he will observe that when the electricity flows from the battery, B, through the primary circuit, 10, and around the bundle of iron wires, Q, that these iron wires will be temporarily magnetized. This bundle of wires that forms the core is very soft, and will lose its magnetism almost instantly. After this slight digression we will again refer to figure 23.

In figure 23, C, is the Ruhmkorff coil with a primary circuit, 10, in which is included: battery, B, regulating screw, R, stud, S, which supports (through the medium of a sensitive spring) the soft iron disc, I. This disc is supported directly in front of, and about 1-8 inch from the soft iron core, Q, of the coil, C. The regulating screw, R, is set so as to make contact with the soft metal armature, I, when no current is flowing through the primary coil, 10. When the current does begin to flow through the circuit, 10, the regulating

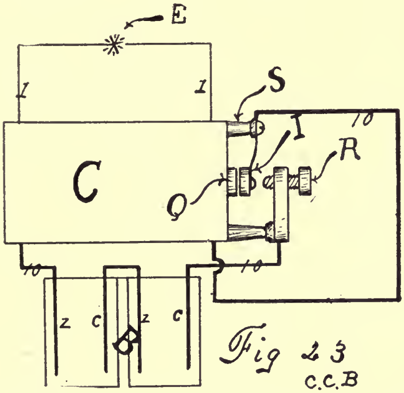


Fig 23
C.C.B

screw, R, and soft iron armature, I, to the stud, S, thence through the primary coil of the transformer, C, back to the battery, the core, Q, of the coil, C, will be magnetized; as previously stated regarding core, Q, in figure 21. This magnetization of the core will cause the soft iron disc or armature, I, to be attracted toward the core, Q, as shown in figure 23, thus breaking the primary circuit, between the soft iron armature, I, and the point of the regulating screw, R. As in the previous instance this break will cause a spark at, E, in the secondary circuit, 1. When the soft iron armature, I, leaves the point of the regulating screw, thus interrupting the electric current, the core will lose its magnetism, thus allowing the armature, I, to again make contact with the regulating screw, R. The described series of operations will then again be rapidly repeated. The regulating screw, R, is for the purpose of obtaining a more or less rapid make and break, according to the tension of the spring carrying the armature, I. In figure 22 and figure 23, the spark, E, is supposed to occur within the combustion chamber of the motor, and in order that this may be accomplished without leakage of the electric current, due to its high pressure, a sparking plug is employed.

In figure 24, we show a sectional drawing of a good sparking plug. B, is a metal shell preferably of brass, threaded at, B′, so as to screw closely into the combustion chamber of the motor, and having a flange, b, turned true with the thread on the shell. The edge of this flange should be cut hexagonal, so that a wrench can be used to screw the plug into the combustion chamber. The brass shell is prolonged at, b′, which should be bent in the form shown. The shell should be counterbored as shown to take the tapering porcelain plugs, P, P, and these plugs should be ground to a fit. Through the porcelain plugs passes a wire headed at one end, C, and threaded at the other end to fit some suitable nut and check nut. There is placed an asbestos washer between the head, C, and the porcelain plug, P, while there is a similar asbestos washer inserted between the metal washer, D, and the other porcelain plug. The asbestos washers are lettered, A. These washers serve the double purpose of preventing leakage through the plugs, and at the same time allowing a slight flexibility to the whole arrangement, thus preventing breakage of the porcelain plugs due to the expansion and contraction, which defect is so obvious in the sparking plugs now on the market.

One end of the wire from the secondary coil is connected with the point, C, of the sparking plug by inserting it between the nut and the check nut, F. The other end of the wire from the secondary coil is connected to some part of the motor casing. The electric current from the secondary coil will travel through the wire connected with the nut, F, to the knob, C. It will then jump across the spark gap, E, to the finger, b′, thus causing the desired spark, and through the motor casing to the other end of the secondary coil. The point of the knob, C, and the point of the finger, b′, should each be capped with platinum, as this metal oxidizes but slightly.

We have treated this matter of the secondary spark and shown the general construction of the coil, and of a good sparking plug for the benefit of those that already have gasoline motors in which the secondary form of ignition is employed.

There are so many motors on the market in which this form of ignition is employed, that we have decided to go into the matter at some length in order that those of our readers that have previously had trouble with such an arrangement, and there are many of them, may possibly

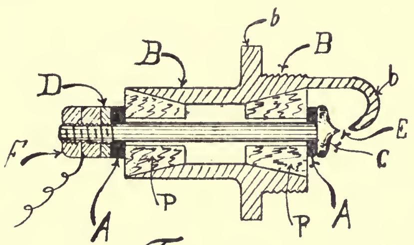


Fig. 24.
C.C.B.

be better able to guard against difficulties in the future.

PRIMARY SPARK OR SECONDARY SPARK?

In the case of the primary spark the current is used at low pressure and there is little danger of leakage, or what is called technically, a short circuit. It should be remembered that wet, or even damp, surfaces are conductors of electricity at high pressure, so this freedom from leakage enjoyed by the low pressure, or primary, system is of great importance. This fact is of double importance on damp or rainy days. The second advantage of the primary system of electric ignition is due to its simplicity. The third advantage is due to the freedom from disagreeable shocks that the operator experiences whenever he comes into contact with metal parts carrying a high tension current. The primary system has one disadvantage over the secondary system. With primary electric ignition it is necessary to have a movable contact within the combustion chamber of the motor, and a packed joint or gland is thus required. This single defect does not begin to be so objectionable as is the trembler necessary when the secondary current is employed, so we have no hesitancy in saying that the primary system has the distinct advantage over its rival, and it is this method that we shall fully describe, with full working drawings, in connection with the motor we are to show how to build.

CHAPTER VI.

Method of Obtaining Electric Current.

There are three methods of obtaining the electric current. Of these methods, two generate the current as it is required, while in the third method the electricity is stored in a storage battery similar to the batteries used in the electric carriages, only much smaller. A battery of primary cells may be used, in which the electrical pressure is obtained by chemical means, due to the consumption of zinc. Or the electrical pressure may be obtained by mechanical means, through the agency of a small dynamo or magneto-electric machine, driven by the gasoline motor.

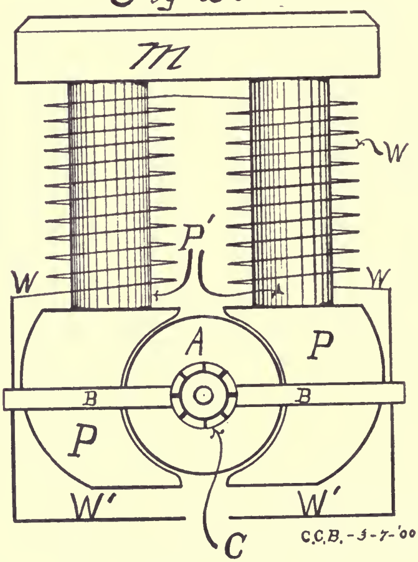
THE PRIMARY BATTERY.

There are many forms of battery which are more or less suitable for making the electricity that is used to fire the gas in a gasoline motor, but in the writer's opinion, the most satisfactory for this work are those wherein a solution of sal ammoniac serves as the active chemical agent. There are three types of cells of this description; the ordinary liquid form, the dry cell and the semi-dry cell. If the chemical agent is in a liquid state, the cell is undesirable because it is impossible to prevent the liquid from splashing out when the vehicle is driven over rough roads. This trouble does not exist in the dry cell, but this type of cell is usually very short lived because there is no circulation of the chemical agent, and that part nearest to the zinc plate soon loses its strength, due to its action on the plate. This defect is not apparent in the semi-dry cell because the chemical agent is in its liquid form, while it is prevented from spilling by the introduction of excelsior, cocoanut fibre, or some similar material to prevent the liquid from moving as a body. This form of cell is usually sealed with pitch, which further prevents the contents, technically known as "electrolite," from spilling.

In cells having sal ammoniac as the electrolite there is little chemical action when not in use, and this is the reason that such cells are desirable. This advantage is due to the fact that a film or envelope of ammonia gas soon surrounds the zinc, thus protecting it from the action of the electrolite. When the cell is in use this ammonia gas is transferred from the zinc to the carbon plate, from which it rises and escapes into the atmosphere through a vent in the top of the cell. The points to be observed in selecting a battery for gasoline motor ignition are as follows:

Be sure the cells are fresh. Select a type of cell that offers a large surface of zinc and carbon to the action of

Fig. 25.

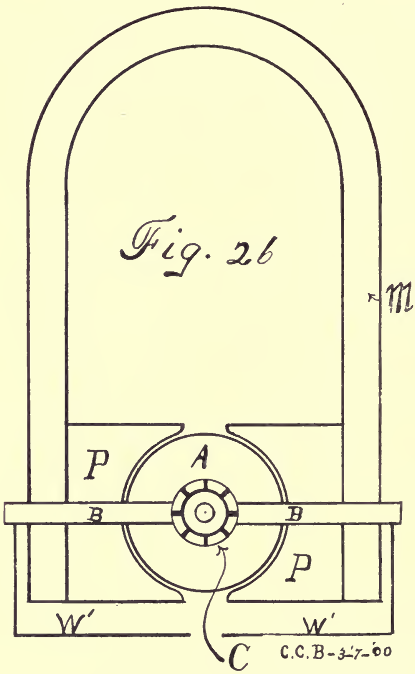


the electrolite. The ordinary door bell cells which have only a small rod of zinc are not at all suitable for our work. The quantity of electricity varies with the area of surface of zinc exposed to the action of the electrolite. In a well designed cell, the surface of zinc and the surface of carbon is large, and these plates are placed close to each other, but must not touch, and the whole must be so arranged that the electrolite may freely circulate. These conditions are fulfilled in one or two cells now on the market.

The most satisfactory way to generate the electric current is by use of a dynamo electric machine. The sparking dynamo is made in two forms. The style usually advertised is shown in figure 25, in which the field magnet, M, is an electro magnet, in which the magnetism is imparted to the pole pieces, P P, by means of an electric current flowing through insulated wire, W, wound around the cores, P′, of the magnet, M. The electric current is obtained from the brushes, B, which also deliver the current to the wires, W′, that are fixed to the connections of the sparking device. The brushes, B, bear upon a series of copper segments, C, which are arranged in a cylindrical or drum form. Each of these segments is connected to one end of the coil wire that is wound around the armature, A. The segments rotate with the armature and the group is known as the "commutator," and its purpose is to convey the current from the armature to the stationary brushes, B.

The action of the machine is as follows: When the armature, A, is rotated a small electric current is generated within it, which flows to one of the brushes, B, thence around the magnet, M, to the other brush, B. In flowing around the magnet it causes the pole pieces, P P, to become more strongly magnetized. This causes the armature, A, to deliver a more powerful current, which in turn causes the magnet, M, to become still more powerful, until a limit is reached for the particular speed at which the armature is driven. If, however, the speed of the armature, A, is increased or diminished the variation in pressure in the wires, W′ will be much more than the variation in speed, because for every variation the magnetism of the pole pieces, P P, becomes greater or less, according to the speed. As the current depends upon the strength of the magnet, M, and the speed of the armature, A, it will be seen that it is necessary to drive such a machine at nearly a constant speed. While such a machine may be suitable for sparking a stationary or constant speed motor, it is undesirable for motor vehicle uses. It may be said that such a machine is not desirable for any purpose where the speed of the driving motor varies to any great extent.

A magneto machine differs from a dynamo in one essential only. Instead of the magnet, M, being made of soft iron, wound with insulated wire, as in a dynamo, see figure 25, it is made of hardened steel and is permanently magnetized by the manufacturer. A magneto machine is thus less complicated than is a dynamo. In figure 26, we show in diagram a magneto that may be used for gas motor ignition. It consists of the steel field magnet, M, just mentioned, to the free



ends of which are bolted the cast iron pole pieces, P P, which must be in good metallic contact with the steel magnet, M. In the gap between the pole pieces, P P, is the armature, A, which is free to rotate without touching the pole pieces. This armature is preferably constructed of thin disc like soft iron stampings, that are threaded on a central steel shaft. This shaft carries the armature which is free to rotate as before stated. The soft iron stampings that form the armature have channels formed in them, and in these channels is wound a considerable length of insulated copper wire, the ends of which are connected to a series of copper bars fixed in drum form at the end of the armature, A, concentric with the armature shaft. This group of copper bars is known as the commutator, and it is shown at C, figure 26. Two conducting brushes bear against the periphery of the commutator, and make electrical contact with it. To the brushes, B, are connected the wires, W′, which lead to the sparking mechanism.

In speaking of the dynamo, shown in figure 25, we mentioned as a serious objection the fact that the faster the armature, A, is caused to rotate, the more powerful will

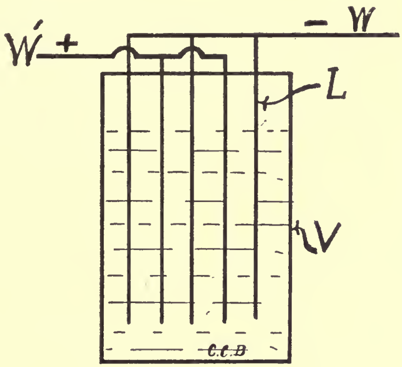


Fig-27.

become the magnet, M. In the magneto machine shown in figure 26, the speed of the armature plays no part in the strength of the magnet, M, because the magnetism in this permanent magnet was imparted by the builder, and is not increased when the machine is working. One cause for irregularity is thus eliminated. The current, flowing through the circuit, W′, will vary almost directly as the speed. The significance of this fact will be better appreciated when we state that a good magneto, constructed as shown in our diagram, will make a good spark if driven at 600 revolutions per minute, but the machine may be run as fast as 3,500 revolutions per minute without overheating. If a dynamo as shown in figure 25 will give a good spark at 1,300 revolutions per minute, and this is the speed usually required, it will be unsafe to run the machine at a speed much in excess of 1,600 revolutions per minute, because at higher speeds the excess of current generated is liable to melt the wire on the armature. Another distinct advantage of the magneto machine is due to the fact that it will generate its full current much quicker than will the dynamo shown in figure 25, because the magnet, M, of the magneto type is at all times energized, whereas, in the figure 25 type, the full current cannot be generated until the magnet has become fully energized or excited, to use the technical term, by its own current.

THE STORAGE BATTERY.

In figure 27, we show, graphically, the arrangement of the elements of a storage cell. Such a cell consists of a containing vessel of glass, vulcanized rubber, porcelain or other insulating material, and it contains a series of lead plates, L. All of the odd plates are connected to the wire, W, and the even plates are connected to the wire, W′. The cell is filled with a solution, usually of four parts of water to one part of sulphuric acid, and it should be then hermetically sealed, or nearly so, in some convenient way. The only difference in storage cells is in the form of the plates, L. These plates are made in hundreds of different ways, all with the object of presenting as much surface to the action of the liquid as is possible.

A storage cell is of no use until it has been charged by a current of electricity. The manner of charging is shown in figure 28, in which, S, is the storage cell, and, P, is a primary cell, or other source of electricity. The terminals of the cell, P, are directly connected to the terminals of the storage cell, S, and continued so connected for four or five hours, when on disconnecting the cell, P, it will be found that the storage cell, S, has stored or accumulated, the current from the primary cell. Provided the storage cell is in good condition, and is handled with care, and is kept in a dry place, etc., it will hold its accumulated current for some time, but unless these precautions are followed the storage cell will be found to be decidedly unsatisfactory. French and German motor vehicle builders frequently use storage cells in their carriages, and it is because of this fact that we have mentioned them.

CONNECTING PRIMARY CELLS TO FORM A BATTERY.

A battery is a group of either primary or storage cells, so connected up that the battery gives a current equal to the united effort of the cells employed. There are two ways of grouping the cells. One method is by connecting them in series, as shown in the primary cell diagram, figure 29. On reference to figure 29, it will be seen that the carbon plate of cell, A, is connected to the zinc plate of cell, B, and that the carbon plate of B is connected to the zinc plate of C. The carbon plate of C is thus left free, as is also the zinc plate of cell, A, just as if a single cell were employed. The advantage of this system of connection is that if cell, A,

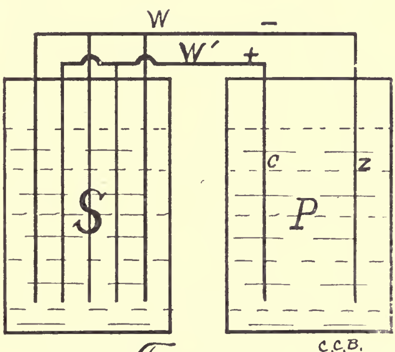
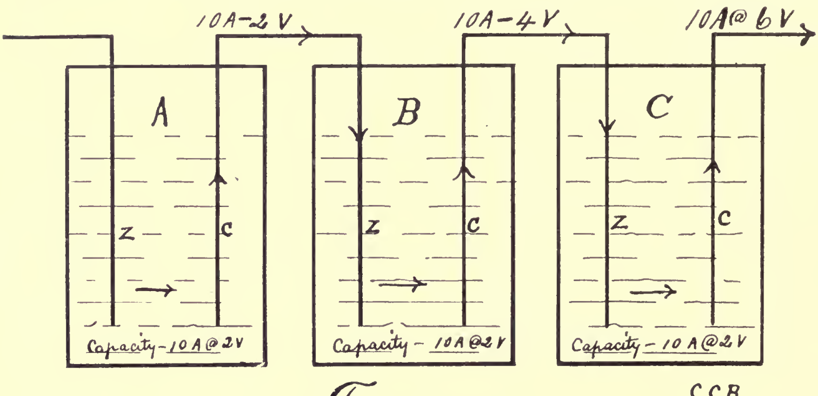


Fig. 28.

has a pressure equal to 2, and cells, B and C, each have an equal pressure, that the effort of A and B will equal 4, while the united effort of the three cells will equal 6.

In electrical parlance the word "volt," derived from the name Volta, an Italian electrician of many years ago, is used as a unit of pressure. Just as the word pound is used as a unit of pressure when dealing of hydraulic, compressed air, or other fluid systems. The pressure in an ordinary cell is usually about two volts, and the system of connections shown in figure 29, is such as to increase the pressure in a direct ratio to the number of cells added, provided they are connected in the manner shown. Our readers will do well to remember what we said before, that is, that these cells are shown connected in "series," and cells should be always so connected when increased pressure is wanted. This system is usually employed in motor vehicle electrical work.

Electricity has quantity as well as pressure, just the same as water or air has. To say that water was flowing through a street main at 80 pounds pressure would give no idea of the amount of power that would be generated by it unless it was known how much water was flowing at 80 lbs. pressure. Thus if one gallon per minute flowed through the pipe at the mentioned pressure, it would represent but 1-10



Fig—29.

as much energy as would ten gallons of water flowing through the pipe at the same pressure. In other words, quantity is of as much importance as pressure.

This fact applies as well to the electric current, but we must use a different word to express the same meaning, when dealing with electricity, than we do when speaking of water, because water has bulk and may be measured in gallons, whereas electricity has quantity but no bulk. The French word, "ampere," derived from the name of an eminent French electrician and scientist, is used as a unit of quantity.

In figure 30, we show cells connected to form a battery in multiple. It will be noticed that all of the carbon plates are connected to one wire, while all of the zinc plates are

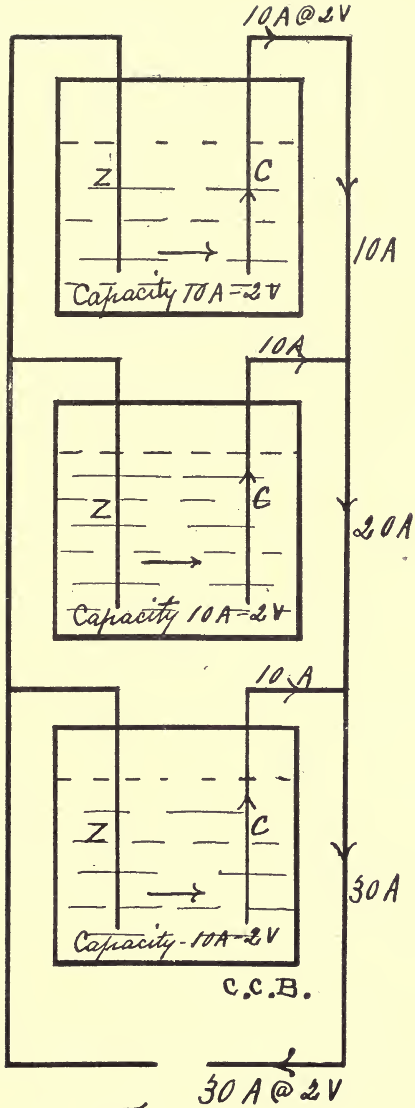


Fig - 30.

connected to another wire. The result is that instead of each cell increasing the pressure, the pressure remains about the same as if there was but one cell used, that is about 2 volts, whereas the quantity of current is equal to the combined effort of the three cells. Suppose the cells will each give 10 amperes, then their united effort will equal 30 amperes. It will, however, be noticed that whatever we gain in quantity over the cells connected in series, we lose in pressure, but the product of the pressure multiplied by the quantity is the same in each case. Viz.: in figure 29, we have at our command a current of 10 amperes at 6 volts pressure, which gives us a product of 60. In figure 30, we have a quantity of 30 amperes at a pressure of two volts, which also gives us a product of 60. As the amount of work done is the quantity multiplied by the pressure, it will be seen that as far as efficiency goes one system is as good as is the other, but in motor vehicle work it is usually better to connect the cells in series, as is shown in figure 29.

CHAPTER VII.

Relative Efficiency of Transmission Devices.

FRICTIONAL DEVICES.

In figure 31, we show a plain belt transmission, in which, A, is the driver, C, is the driven pulley and, B, is the belt.

In figure 32, we show the same arrangement of pulleys, but in this case the belt, B, is crossed. A combination of these two systems is much used in some of the French and German vehicles for obtaining, with the direct belt drive, figure 31, a straight ahead motion of the vehicle and with a crossed belt, as shown in figure 32, a backward, or reverse, movement of the vehicle.

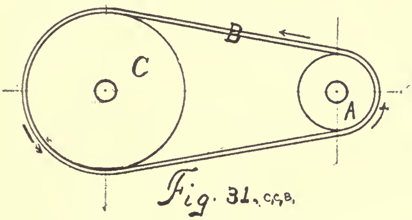


Fig. 31. C.C.B.

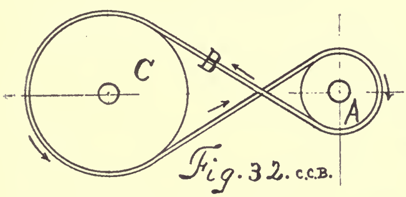


Fig. 32. C.C.B.

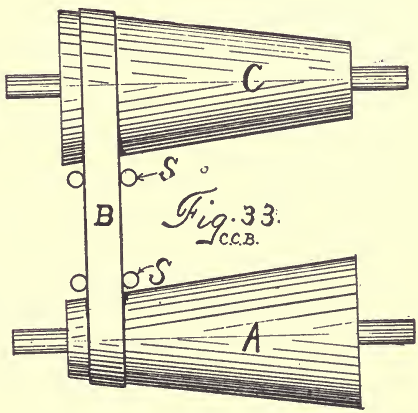


Fig. 33. C.C.B.

Different speeds may be obtained by varying the relationship existing between the driving pulley, A, and the driven pulley, C. This may be also accomplished by substituting wide conical pulleys, A and C, figure 33, for the ordinary pulleys, A and C, shown in figure 31. In this last instance the speed of, C, depends on the position of the belt, B. If this system of conical pulleys is used it is necessary to employ a double belt shipper shown at, S S, in order that the belt may be kept parallel.

In order that the vehicle may be started and stopped without stopping the motor, it is usual to use a fast and a loose pulley, as shown in figure 34. In this figure, A, is a pulley of double the width of the pulley, C. The pulley, C, may be started or stopped by shifting the belt from or to a loose pulley, C′. When the belt is running on the pulley, C′, the vehicle will not move, but it may be started by shifting the belt, by means of the shipper, S, to the driven pulley, C, which is attached to the shaft, D.

In figure 35, we show another frequently used method of starting and stopping a belt driven vehicle, in which, A, is the driving pulley, C, is the driven pulley, B, is the belt and, I, the idler, or jockey pulley, mounted on the lever, L, in such a manner that it may be pressed against the belt, B, so as to tighten it, whereas by lifting the idler free from the belt the pulley, A, is free to rotate without driving C, due

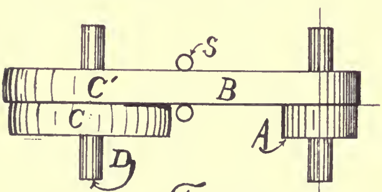


Fig. 34. C.C.B.

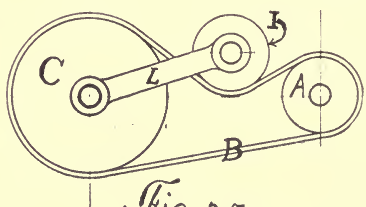


Fig. 35. C.C.B.

of course to the slackness of the belt. The device shown in figure 35, has the advantage of adjustment over the arrangement illustrated in figure 34. The length of a belt is affected in wet weather and by other climatic changes, and the jockey pulley device is useful in making allowance for these changes. Of course it has the disadvantage of adding one extra part to the mechanism, and there is also considerable friction in this device, due to the pulley rotating inside the belt when the belt is very slack.

BELTS IN GENERAL.

In order that a belt may run true on its pulleys, it is necessary that the driving and the driven pulley should each be in line with the other, and that their surfaces should be curved, as shown in figure 34, at, C. The belt should be thin, wide and long. The driving pulley and the driven pulley should each be of large diameter, thus insuring a rapid speed of the belt, B. To secure the best results each pulley should be leather covered wherever practicable, and the belt should always be protected from the rain, dust and mud. If these conditions are carefully fulfilled belts can be successfully used on light vehicles with more or less satisfaction, and it is worth some trouble to have a transmission that obviates the use of clutches, and that will run quietly, a very good point about belt transmission.

FRICTION DISCS.

In figure 36, we show one form of friction disc arrangement in which, A, is a flexible roller mounted on the motor shaft, A′, in such a manner that it will contact with the surface of the disc so as to drive the disc, which is preferably

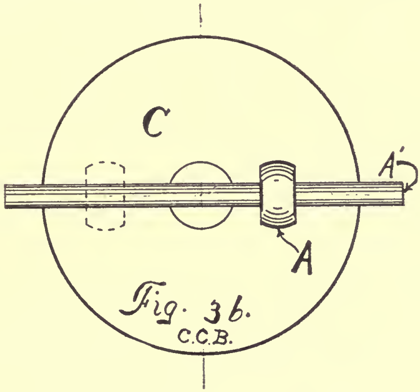


Fig. 36.

leather covered and turned off true. It is obvious that as the pulley, A, is moved to the right or to the left of the position shown, the disc, C, will rotate faster or slower, whereas if the pulley, A, is moved to the other side of the disc, C, to the position shown in dotted lines, for example, the disc will rotate in the opposite direction, thus giving, as desired, a backward or forward motion to the vehicle. Although this device and its many modifications has been a very alluring thing to many motor vehicle designers, still we advise our readers to let it severely alone, as at the best calculation about 50 per cent of the power of the motor is absorbed in such a device. It is a handy way to drive low powered mechanism, such as a magneto for making the electric spark.

POSITIVE MEANS OF TRANSMISSION.

The familiar chain drive. This is probably the most efficient method known of transmitting power from one shaft to another, but in order that it may be thus efficient, it is necessary that the chain should be properly encased, and kept free from dirt or dust, and it is also necessary that the sprocket wheels, on which the chain runs, shall be accurately cut, and that the chain itself should be very carefully made, and preferably of the roller variety. It should be of as fine pitch as is consistent with the power to be transmitted. If the above conditions are all fulfilled, together with well designed ball bearings for the shafts, the remarkably high efficiency of 95 per cent may be attained.

It must, however, be understood that a very small amount of dust or dirt causes this degree of efficiency to fall off to a considerable extent. This loss is even more noticeable in a block chain than in a roller chain. The great disadvantage in using sprocket chains for motor vehicle use is due to the fact that such chains lengthen, because of the wear on the great number of joints in them. Some means of adjustment is therefore necessary, which is always an undesirable feature. This is especially true when two or more chains are used, because they never lengthen equally, consequently they can never both be running under the same conditions. Again, when the rivets wear slightly the pitch of the chain becomes slightly greater than when new, and for this reason they will not run with the high degree of efficiency we have stated. It will be thus seen how necessary it is that the chain should be properly protected.

A great advantage of the sprocket chain drive is its comparative quietness in running. When the driving and driven shafts can be so arranged as to be near each other, a spur gear drive, is perhaps the most satisfactory known method of transmitting power. When such gears are used the following conditions should be observed. Be sure that the shafts are not only parallel, but that they are in the same plane, and be very careful to have the bearings rigidly connected in such a manner that twisting, due to the uneven roads, or due to the torsional strains within the gears when running, cannot throw the shafts out of line. In other words, the teeth must always bear along their full surface in order to obtain the best results. If noise is to be obviated when gears are used, one of the gears, usually the smaller, should be made either of fibreoid or of rawhide, and both should be accurately cut by some responsible concern that makes a business of this kind of work. It is even more important that gears should be encased than it is that a sprocket chain should be. To obtain the best results from any style of gear it is best to enclose them in a dust-proof casing in which a mixture of thick grease, such as Albany grease, and graphite is introduced. If the above precautions are observed, in the use of gears, and if the shafts on which they are mounted, rotate in well designed ball bearings, an efficiency of from 92 per cent to 94 per cent may be had.

Our above remarks apply both to internal gears and spur gears. The advantages of the former are four-fold: First, as the center of the pinion lies within the circumference of the internal gear more teeth will be in contact at the point where the power is transmitted than would be the case were spur gears substituted for the internal and pinion. Second, internal gears make less noise when running than do spur gears on account of the teeth of the pinion approaching and leaving those of the gear much more gradually in the former type than in the latter. Third, on account of the pinion being within the circumference of the gear, the driving and driven shafts may be put nearer together when internal gears can be used than when other methods are employed. Fourth, on account of the teeth of the gear overhanging the teeth of the pinion in this type of transmission, a fairly good mud-guard is formed by the periphery of the gear without the use of a mud-guard.

It will be observed that all the methods of transmission so far mentioned necessitate the driving and driven shafts being parallel to one another; when, however, they are of necessity at an angle to one another, bevel gears are usually employed to transmit the power from the one shaft to the other. In this type of gearing there is more loss than in the others just described, owing to the end thrust tending to push the gears from each other. In order that such gears may work economically, ample means should be provided for taking up this end thrust, and in cases where the best results are required it is necessary to employ a ball bearing end thrust. When this is done, and when the precautions already referred to in connection with the other methods of gearing already considered are followed, a relatively high efficiency may be had from bevel gearing. This efficiency, however, seldom exceeds 85 per cent, and then only under nearly ideal conditions.

Another method of transmitting the power when the shafts are at still a different angle is by means of the worm and a worm gear, such as is used in elevators. The efficiency, however, of this combination is generally low, not as a rule exceeding 70 per cent. This low efficiency is due to the sliding action that takes place between the teeth of the worm gear and the threads of the worm. On account of this sliding action it is necessary that the gear and the worm should be carefully fitted with an oil well in which a thick, heavy grease is used. It is also necessary to provide, in a thorough manner, against the end thrust on the worm, as the end thrust in this case is even greater than with bevel gears. The two chief advantages of worm gearing are: First, the ease with which the high speed of the motor may be reduced at once to the slow speed necessary for the wheels. Second, the very quiet running of such gearing. These advantages are, however, more than counterbalanced by the enormous wear and loss of power usually found in this method of gearing.

SUMMARY.

While worm gearing or bevel gearing may be necessary with certain designs of vehicles, we strongly advise the reader to avoid their use if possible. And we recommend any of the other methods of transmission named. We would especially recommend spur gearing or the internal gear mechanism, but when the driving shaft and the driven shaft are far apart, it is better to use a sprocket chain than to cover the distance by a train of gears.

CHAPTER VIII

Elements of Power.

THE POWER OF A MACHINE.

Up to the time of the invention of the steam engine by James Watt, there was no satisfactory means of measuring or expressing the power required or delivered by any of the few machines then in use; and the only means of obtaining motive power was either by means of windmills, water-wheels, manual labor, or else, the most common of all, by horses. This latter means was the one almost universally used by the mine owners for pumping water out of the mines and for bringing up the coal or other material to the surface. As these mine owners were very rich and as the horses they kept to do their work were expensive and troublesome, it was only natural for these men to turn their attention to the new method of obtaining the requisite power to operate their crude mining plant. What is the power of your engine? was asked by all. "We have so many horses, will your engine do the same work?" This was the question asked of Watt, and it is what the prospective purchaser of a motor vehicle is asking today.

It will be of advantage to us to consider the means the world-renowned Scotchman employed to find the power of his engine. In the first place he decided that the horse should be his best unit of power. Having decided this, it was necessary to find out how much power a horse had. For this purpose he sent down to London for a number of large draft horses, whose power he proposed to test by causing them to lift weights by means of a kind of derrick. He very soon found that the horses could raise enormous weights when required, but that they soon became tired if overworked, and as a result their work under such conditions would not equal in a day of eight hours what it would if the load was reduced and the work made continuous. After many tests and measurements Watt found that a powerful horse could lift a weight of 33,000 pounds one foot in one minute and continue to do it for eight hours, or in other words, a strong horse could in eight hours raise 33,000 pounds, 60 minutes × 8 hours = 480 feet.

Having thus established a standard of work, which is the same as we use today, it was a comparatively easy matter to rig up his engines to raise a weight and thus determine their power. A one horse power motor then is one that is capable of doing an amount of work equivalent to raising 33,000 pounds, one foot high in one minute. We wish our readers to notice that the weight moved, the time occupied in moving it, and the distance it is moved are all factors in determining the power of a machine. In other words, the product of the pull in pounds × the distance in feet through which said pull is exerted, divided by the product of the time in minutes × 33,000 = the horse-power. Another way of putting it is:

$$\frac{\text{(Pull in pounds)} \times \text{(Distance pulled in feet)}}{\text{(Time occupied in minutes) x (33,000)}} = \text{h. p.}$$

Let us take a few examples. Suppose we have a weight, P, of 3,300 pounds, that it is being raised by a rope, on which it hangs, at a rate of ten feet a minute, then we have

$$\frac{\text{(Pull=3,300 lbs.)} \times \text{(Distance=10 ft.)}}{\text{(Time=1 minute)} \times \text{(33,000)}} = \frac{33,000}{33,000} = 1 \text{ h. p.}$$

Again, suppose we have a weight of 6,600 pounds, which we find by timing is being raised at the rate of 100 feet a minute, we thus have

$$\frac{\text{(Pull=6,600 lbs.)} \times \text{(Distance=100 ft.)}}{\text{(Time=1 minute)} \times \text{(33,000)}} = \frac{660,000}{33,000}\text{, or 20 h. p.}$$

As it is usually very inconvenient to couple the motor with a suitable arrangement for lifting weight, other means of testing the power are adopted, which we shall describe after we have given the detailed drawings of our motor.

An interesting anecdote that has been told will better illustrate our point. When Professor Elisha Thomson, of electrical fame, was working hard upon his motor, some years ago, a storekeeper from across the street entered his shop and saw one of the electric motors running and naturally asked how much power it was developing. He was informed about four horse power. He was not convinced, however, and so taking up a broom that was near by he pressed the straws against a pulley on the armature shaft (the pulley was about 14 inches in diameter) when to his surprise the motor stopped. Professor Thomson endeavored to explain about the speed of the motor, but the wise Pennsylvanian grocer returned to his shop pitying the poor man across the way, who was fooling away his time on a four horse power machine that could be stopped with a broom. For several moons the grocer laughed, but he has probably since then done a good deal of thinking, as the Thomson-Houston Electric Company sold out to the General Electric Company, some years since, for seven million dollars, and yet motor building was its specialty.

Let us see how the story works out according to our rule. Suppose the motor was running at 2,500 revolutions per minute. Then with a pulley 14 inches in diameter the periphery of the pulley would be traveling at approximately $\frac{14}{12} \times \frac{22}{7} \times \frac{2500}{1}$, in which $\frac{14}{12}$ is the diameter of the pulley in feet and 22-7 is 3 1-7 reduced to a simple fraction and represents (approximately) the ratio of diameter to circumference of a circle. The above equation reduced gives us a pulley speed, in round numbers, of 9,166 feet per minute. Taking for granted that our grocer pressed upon the face of the pulley with a force of about 15 pounds, we then have

$$\frac{(\text{Pull in lbs.}=15) \times (\text{Distance in feet } 9{,}166)}{33{,}000 \times (1=\text{Time in minutes})} = \frac{15 \times 9{,}166}{33{,}000} = \text{about}$$

4 1-25 h. p., or 1-25 h. p. more than stated. Now if this same grocer had seen a derrick raising a huge piece of granite weighing 11,000 pounds at the rate of 12 feet per minute, he would probably stand aghast at the thought of the enormous amount of power necessary to do the work. How much power does it require?

$$\frac{11{,}000 \times 12}{33{,}000 \times 1} = \frac{12}{3} = 4 \text{ h. p., or less than he stopped with a broom!}$$

LEVERS.

Heretofore we have been considering power as given or applied by rotating parts, but oscillating levers have been used in motor vehicles, and a few words about them will not be amiss.

In figure 31, we show an ordinary crowbar. Now, all of our readers will know that if we attempt to raise a weight at, A, and we lift at, C, that we can do the work much easier than we could should we move the same weight to the position, B. This we say is due to the fact that we have a greater leverage at, A, than we have when the weight is at, B. But what does this mean? It is the same old story as before. We lift more weight at, A, with the same exertion than we do at, B, but the speed at which we raise the weight at, B, is greater than the speed we raise it at, A, or in other words, we lift the weight a greater distance in feet in the same period of time if placed at, B, than if placed at, A. And as our rule for determining the power of a given device is

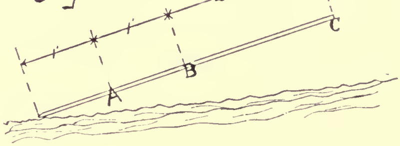


Fig. 31.

to multiply the weight in pounds by the distance the weight is moved in feet we arrive at the following: If we raise a weight of 350 pounds at, A, 1 foot in one minute we do an amount of work=350 foot pounds. But if we move this same weight to the position, B, and then lift the end, C, of our lever, to the same height as before we find that we have had to do an amount of work equivalent to 350 pounds × 2 feet = 700 foot pounds, or twice the work previously done. This then shows that while the task of lifting the weight seemed easier when in the position, A, than when at, B, it really was only apparently so, because in order to move the weight at, A, the same distance we did at, B, we should have to lift it twice, and as it cost us 350 foot-pounds of labor to lift it once, to double it would cost us 700 foot pounds of labor, or the same amount as when we lifted it the full two feet at, B.

ROTATING PARTS CONSIDERED AS LEVERS.

Suppose we have six such levers as shown in figure 31, mounted about a common center, see figure 32, and suppose on lever, 1, we have a weight, as in figure 31, which we have just discussed. It will be evident that if we raise the lever, 1, figure 32, to the position, 6, our same rules apply as to weight and distance as before. Let us now transfer the weight from lever, 1, to lever, 2, which will now occupy the position formerly held by the lever, 1, and repeat our lifting. If we continue this operation until we have gone through it six times it will be evident that we have lifted the weight a distance equal to the circumference of a circle that may be drawn through the several points, A. Suppose we now join the points in the manner outlined and also do the same with the points marked, B, and with the ends of the levers, 1, 2, 3, 4, 5, 6. We will now have three concentric pulleys, A, B, C, figure 33. Is it not logical that these pulleys bear the same relation to each other that the points, A, B, C, did in relation to the lever? One other point must be remembered, viz.: It is equally the same whether the resistance to rotation of the pulley, A, is caused by raising a weight or by driving a belt, as long as the pull in pounds and the speed of the surface of the pulley, in feet, are known. The rule remains the same.

We will take the following instance to illustrate the point: Suppose the pulley, A, to have a diameter of two feet. The pulley, c, a diameter of eight feet. The pull on the driving belt, c, to be 20 pounds. What pull will we obtain on the driven belt? We first ascertain the speed of the shaft on which the two pulleys are supposed to be mounted, in this case we will call it 100 r. p. m. (revolutions per minute). The speed of our driving belt then is $100\times8\times3.14$; where 100 is the shaft speed, 8 the diameter of the pulley, and 3.14 the ratio of diameter of a circle to its circumference. 3 1-7 is often used, as being near enough. $100\times8\times3.14\times20=$

the foot pounds of work done by the driving belt=50,240. Now, our driven pulley is but two feet in diameter, and it is also running at 100 r. p. m., so the speed of its surface equals $2 \times 3.14 \times 100 = 628$ feet per minute. The driving pull on this belt then is obviously $\frac{50,240}{628} = 80$ pounds pull, or 4 times that of the driving pulley.

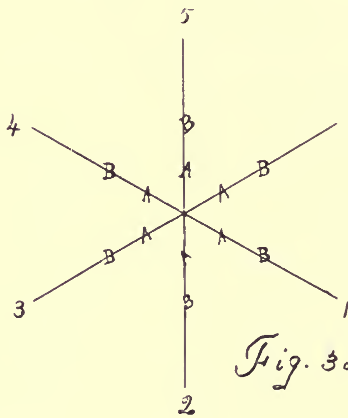


Fig. 32.

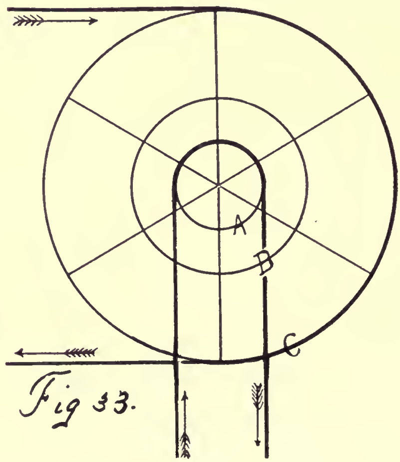
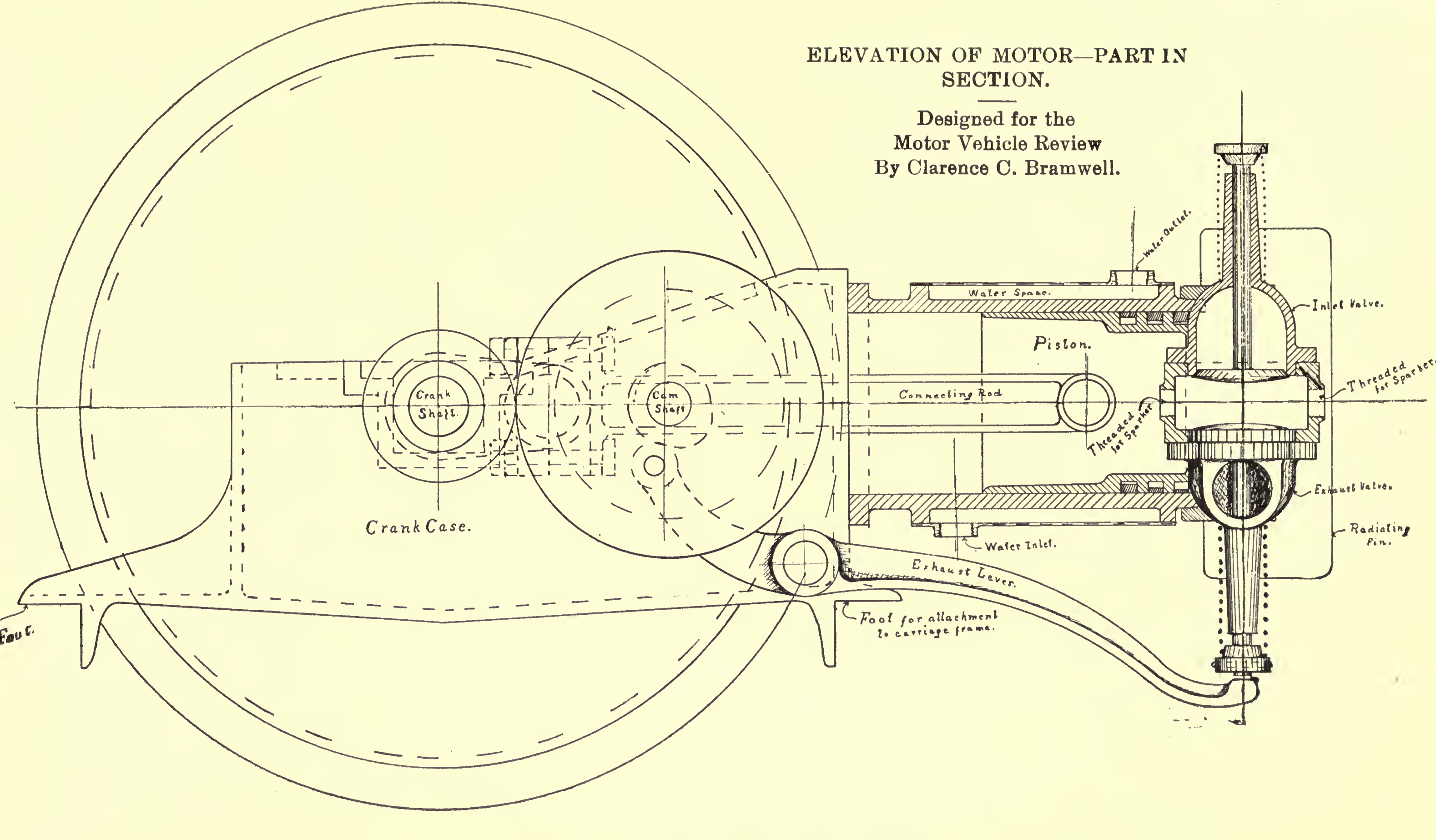


Fig 33.

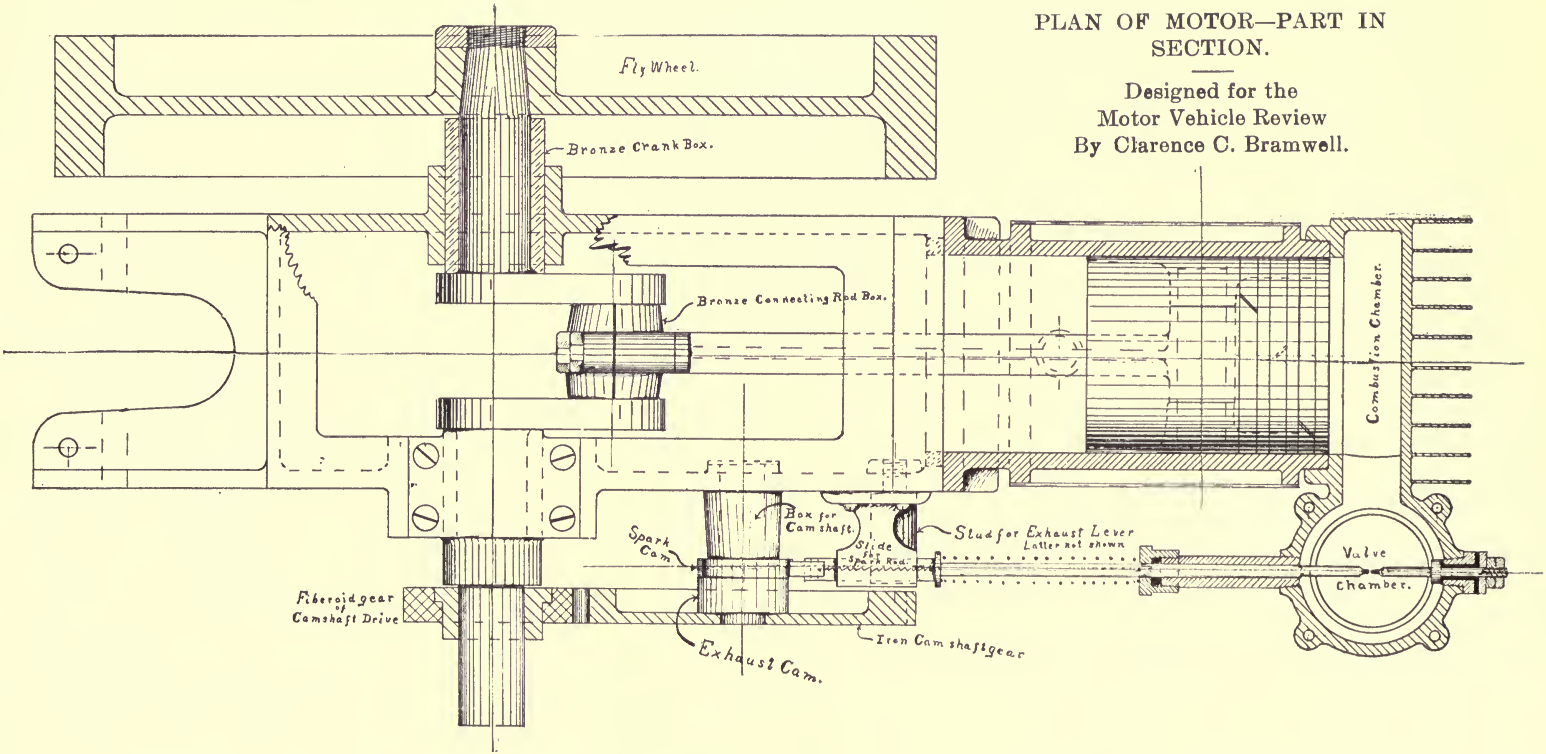
ELEVATION OF MOTOR—PART IN SECTION.

Designed for the
Motor Vehicle Review
By Clarence C. Bramwell.



PLAN OF MOTOR—PART IN SECTION.

Designed for the Motor Vehicle Review By Clarence C. Bramwell.



CHAPTER IX

The Motor.

Before giving the dimensions of the various parts of the motor, we will give our reasons for designing the particular type shown.

In the first place, we show a single cylinder motor: because multi-cylinder motors are not in such general use as the single one. Again, the principle remains the same, the plural being simple duplicates of the single cylinder.

Second, we show the ordinary four cycle motor of the Beau de Rochas, or sometimes called Otto, cycle because this is the only type of machine in the present state of the art that is fit for motor vehicle use. Third, in our opinion, only those motors in which a primary electric spark is used to ignite the gas have any chance of ultimate success, except in a limited degree, with the public.

Many of our readers, on looking over the dimensions we give for this motor, will no doubt think the parts unusually heavy, and quite likely not a few will undertake to lighten the same. To those that contemplate so doing, the writer can only say that the motor here illustrated is the result of nine years' experience with many different kinds and types of gasoline motors, including one cylinder, two cylinder, three cylinder and four cylinder motors, and stationary and rotating motors, as well as unjacketed and jacketed motors. And he has found out, by experience on the road, that the parts must be large, the bearing surfaces ample and the design simple, in order to have the machine give satisfaction. It may not be out of place to further state that the writer has driven a vehicle equipped with a motor of the size herein shown, a distance of more than 2,500 miles over the ordinary roads. The only material difference between the motor he uses and the motor here described lies in the fact that the one on the vehicle mentioned was an unjacketed motor of novel design, but of the same power as the one here described.

We mention these facts because we want the reader to know that the proportions that we show in our drawings are the result of actual road experience, in fair weather and in foul.

TABULATED LIST OF THE DIMENSIONS OF THE MOTOR AS SHOWN IN FIGURES 34 AND 35.

Extreme length, 29 1-2 inches. Extreme width, 15 inches. Extreme height (without fly-wheel), 10 1-4 inches. Distance between feet on crank casing, for attachment to motor vehicle frame, 17 1-4 inches. Diameter of fly-wheel, 18 1-4 inches. Width of fly-wheel, 3 inches. Thickness of fly-wheel web, 3-8 inches. Diameter of fly-wheel hub, 2 1-2 inches; length of same, 1 3-4 inches. Thickness of outside rim of fly-wheel, 1 1-4 inches; thickness of rim on inside, 7-8 inches. Length of crank shaft, 15 inches. Length from fly-wheel end of crank shaft to centre line of motor, 7 1-4 inches. Length from centre of motor to other end of crank shaft, 7 3-4 inches. Length of wrist of crank, 2 inches. Diameter of crank shafts and wrist, 1 1-2 inches.

CRANK CASE.

Extreme length over all, 20 1-4 inches. Distance between center of crank shaft bearing and end where cylinder attaches, 9 1-4 inches. Distance from center of crank shaft bearing to other end partition, 4 3-4 inches. Distance between centers of crank shaft and cam shaft bearings, 5 1-4 inches. Extreme width of case, 5 3-4 inches. Thickness of sides of case, 3-8 inches. Thickness of cylinder end of case, 1-2 inch. Thickness of opposite end of case, 1-4 inch. Thickness of bottom of case, 1-4 inch.

CONNECTING ROD AND PISTON.

Length of connecting rod on centers, 12 1-4 inches. Width of connecting rod boxes, 2 inches. Diameter of piston, 4 1-8 inches. Length of piston, 5 inches. Diameter of wrist pin of piston, 1 inch. Number of piston rings, 3.

CAM SHAFT GEARS.

The small gear, that is, the one attached to the crank shaft, should be 3 1-2 inches pitch diameter, and 8 pitch, giving a total of twenty-eight teeth. This gear should be made of fibreoid, mounted on an iron hub. The large gear should be made of cast iron. It is 7 inches pitch diameter, and has fifty-six teeth. They are each, 5-8 inches thick.

CYLINDER.

Length of cylinder is 8 1-2 inches; 1-2 inch of this length enters the crank case, as shown in the drawing, leaving the cylinder projecting beyond the crank case, 8 inches. Thickness of flange to attach cylinder to crank case, 1-2 inch. Size of flange, 5 1-2 inches square. Outside diameter of cylinder, 4 3-4 inches. Bore of cylinder, 4 1-8 inches. Diameter of thread at end of cylinder for attaching combustion chamber, 4 7-8 inches. Diameter of flanges for water jacket, 5 9-16 inches. Width of the same, 3-8 inches. The water jacket is formed by shrinking a 5 3-4 inch 14 gauge cold drawn brass tube on these flanges. Brass tubes vary slightly, and for this reason it would be better to get the tube before taking finishing cut on flanges, and then fit it perfectly, because it is essential that the joint should be water tight.

THE COMBUSTION CHAMBER.

Distance between center of combustion chamber and center of valve chamber, 4 1-2 inches. Internal diameter of combustion chamber, 4 3-4 inches. Internal diameter of valve chamber 3 inches. Combustion chamber is 1 1-4 inches deep. Diameters of openings in valve chamber to receive inlet and exhaust valves, 2 5-8 inches. Distance between stud holes for attaching valves, 2 5-8 inches. Diameter of studs, 5-16 inch.

Details of valves and spark mechanism will be given later.

A few words of caution to the reader who intends building a gasoline motor will be appreciated by him later, if not at present.

On account of the very high speeds gasoline motors should run, and the consequent rapidity with which the valves and sparking mechanism should act, it is necessary to employ the very finest quality of workmanship that can be had, and as a result a commercial success cannot be expected in manufacturing these motors, excepting by concerns that are prepared to go to a great outlay in preparing special tools and jigs for the work. In other words, the motor bears the same relation to a vehicle that the crank hanger does to a bicycle, or that the wheels do to a buggy. It is the vital part. However, for the amateur that has plenty of time on his hands, and is a good machinist, there is perhaps no more fascinating work than to make with his own hands a good reliable gasoline motor. It is for this class that we are describing our motor in detail, and we merely give him the above caution so that he will not be disappointed if he meets with many reverses before attaining success. If he does succeed in building his motor as it should be built, he will have a thoroughly serviceable machine that will not manifest the crankiness generally charged to gasoline motors. In other words, this crankiness is credited to gasoline motors in excusing poor design and workmanship.

Before going into the details of construction, let us consider the points aimed at in designing a reliable sparking device for use with a low tension electric current, such as we have previously advised using. In the first place, all primary sparking devices consist of two parts, usually termed electrodes, one of these parts is capable of being moved, while the other one is usually a fixture in the combustion chamber of the motor. Again, one of the electrodes, generally the stationary one, must be insulated from the rest of the motor by some suitable non-conducting material, such as asbestos. To this insulated electrode the positive pole of a suitable battery is connected through the medium of a spark coil, whilst the negative pole of the battery may be connected to any metallic portion of the motor.

Suppose we have connected the two electrodes with the battery. Now, in order to obtain a spark it will be only necessary to press the point of the movable electrode against the point of the stationary point and then suddenly separate the points by withdrawing the movable electrode, when a vivid spark will occur between the points.

It will readily be seen that unless some provision is made in the sparker to relieve the blow when the movable electrode is pressed against the stationary electrode, the platinum points with which the electrodes are tipped, would soon be pounded out of shape, on account of the necessary speed with which they must be brought together and again separated when the motor is running at 600 to 1,000 r. p. m.

Another point aimed at, in designing a reliable sparker, is to obtain a quick separation of the points, not only when the motor is running at speed, but also when it is being turned by hand, as in starting. This quick separation must be made in such a way that, should the motor be turned backward for any reason, the operating parts of the sparker will not be injured.

If the reader will refer to figures 36 and 37, he will see one way of obtaining the above results in a comparatively simple and efficient way. In the above figure, a, is a piece of 1-2-inch square steel, 6 1-4 inches long, which has been turned down to 1-4 inch round for 3 1-2 inches of its length. This 1-4-inch portion fits loosely into a 3-8-inch 16 gauge steel tube 7 5-8 inches long. Into the other end of this tube a 1-4-inch piece of cold rolled steel, 2 inches long, is brazed, and this latter is tipped with platinum on its outward end. The platinum being a piece of 10 gauge wire 1-4-inch long.

Between the end, a′, of, A, and the inner end of, B″, is placed a light open helical steel spring, D′, which should fit the tube, B, loosely. This spring should be compressed slightly and while in this condition the pin, a″, is driven crosswise through the rod, a′, so as to fit tightly in the latter, but loosely in the slot, B″, of the tube, B. (There is a slight mistake in the drawing here, as the cone, B′, should be shown as attached to, A, thus moving with the piece, A, and a′. It will be thus seen that the spring, D, virtually presses against, A, and that, a′, being free to move within the tube, B, causes the pin, a″, to move toward that end of the slot, B″, nearest, A, before the platinum point is withdrawn from contact with the stationary electrode. But when the cam moves, A, upward, or toward the stationary electrode, there is left between the pin, a″, and the remote end of the slot, B″, a sufficient space for the cushioning effect

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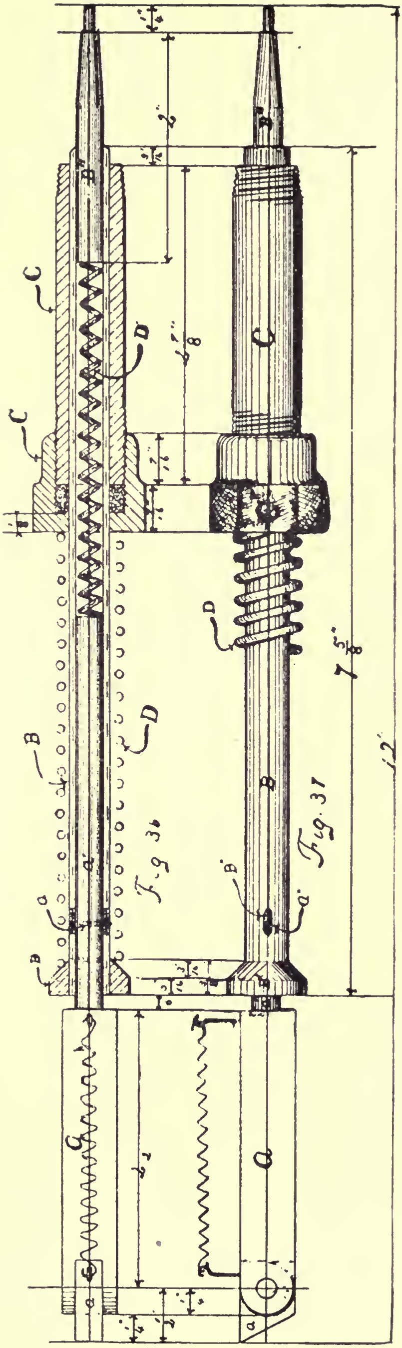


Figures 36 and 37.
Movable Electrode.

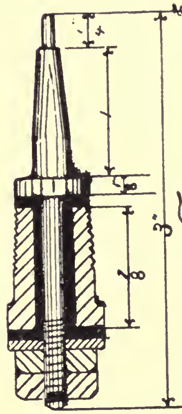


Figure 38. Stationary Electrode.

of, D′, to act.) The other end of, D, presses against the cap, C′, of stuffing box. This stuffing box is formed on outward end of the brass tube, C, whose inner end is threaded with a tapering thread so as to fit gas tight in the valve chamber. The cap, C′, should fit the threaded part of C, rather closely, so as not to unscrew by the vibration, while its outward end is made hexagonal, or square, so as to admit of using a small wrench to tighten the gland.

It will be noticed that the outward end of, a, carries a trip, or pawl, a, that is so held by a small spring that if an upward strain comes on its slanting face it will maintain the position shown in the drawing, while, on the other hand, should a downward strain come on its face, it will bend downward and so relieve any tendency to break, a, or the foot through which, a, slides as shown in the drawings of the complete motor. These latter drawings also show the cam for operating this movable spark member.

It will be noticed that should a pressure be brought against, a, so as to tend to force it toward, B″, and the platinum point of the latter should meet the opposing stationary platinum point carried by the stationary insulated electrode, figure 38, that these two points could only press against each other with a force equal to that exerted by the spring, D′. If the pressure now holding the points together is suddenly relieved, the spring, D, will quickly draw the point of, B″, away from the stationary point, thus causing a spark if the current is on.

Figure 38, is self-explanatory. It is only necessary to say that, that portion shown in black is asbestos, and is for the purpose of insulating the central stem from the outside casing which is threaded so as to screw into the valve chamber of the motor, as previously shown.

EXHAUST LEVERS.

For a clearer understanding of the motor, the lever which opens the exhaust valve, is here more specifically described.

Referring to figures 39 and 40, A, is the lever. B, is a part section of the crank case, which carries the boss, b, into which is riveted a steel stud, C. This stud should have a shoudler, c, which bears against the outside of the boss, b, thus making a very strong construction. The short end of the exhaust lever carries a boss, F, into which is riveted a second steel stud, E, in the manner shown. Between the head, e, and the boss, F, is carried a steel roller, D, so arranged that it may freely rotate on the stud, E. This roller, D, bears against the exhaust cam, previously shown. The long end of the lever carries a boss, H, that bears against the end of the exhaust valve stem, so as to open the valve when required.

Following will be found the dimensions of the various parts.

The end of the stud, C, which is riveted into the boss, b, is 1 1-8 inch long, 1 inch diameter. The shoulder, c, is 1 1-2-inch diameter × 1-4-inch thick. The projecting end of the stud, on which the lever oscillates, is 1 3-4-inch × 1-inch diameter. The stud, E, is 3-4-inch long × 1-2-inch diameter, at that part of its length that is riveted into the boss, F. That part on which the roller, D, rotates is 5-8-inch diameter × 9-16-inch long. The head of the stud is 1-inch diameter × 1-8-inch thick. Preferably this stud is case hardened, as also the roller, D. This roller is 1 3-8-inch diameter × 9-16-inch thick, and is drilled to be a good running fit on the stud, E. The lever, A, should be made of some good cast steel, but may be made of cast iron, provided it is made about 30 per cent heavier than the dimensions here given. The web, a, is 1-4-inch thick, while the rib, a′, is 3-16-inch thick. The boss, H, is 5-8-inch diameter. The hub, I, is 1 1-2-inch diameter, while the hub, F, is 1-inch diameter.

We shall now deal with the designing of gasoline motor vehicles, as we believe that there are many mechanics at this time who are trying to build a vehicle for their own use, but who, finding but little information available, and that little at considerable variance, are, so to speak, "like a fish out of water," floundering about and not knowing which way to turn. There is only one way, and that is up-hill, where it is slow traveling, and cannot be hurried; kicking and fuming simply distract one's attention and cause extra delay. Again, one must begin to design a motor vehicle with the understanding that there are two or three things he is going to

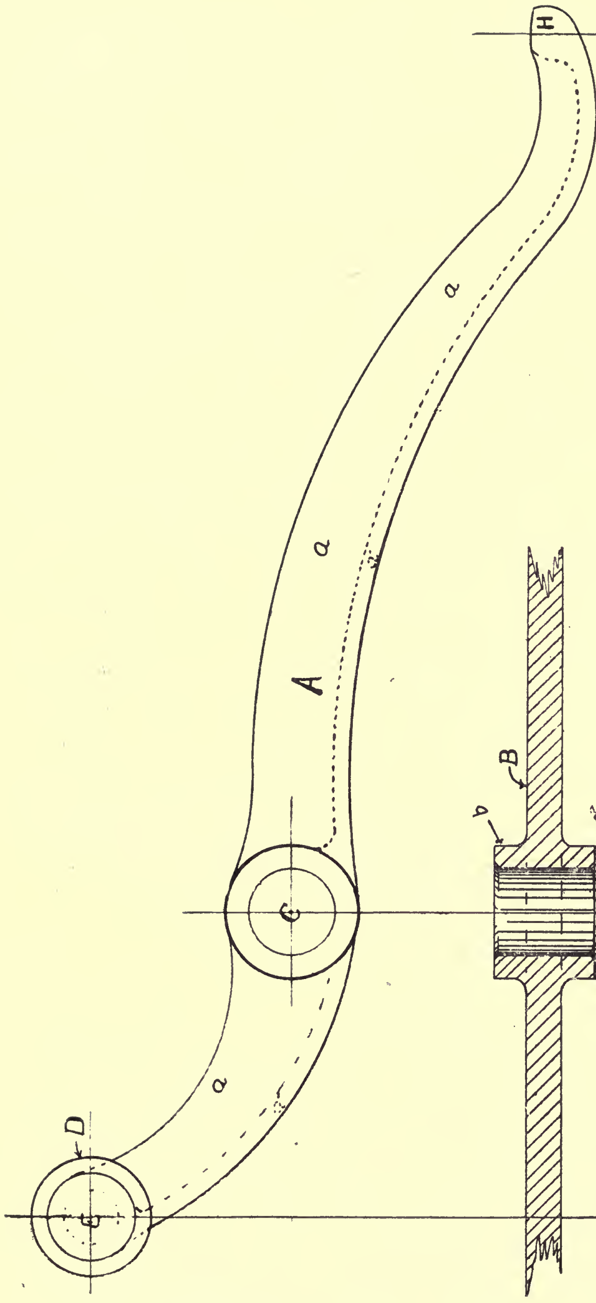


Fig. 39. Elevation.

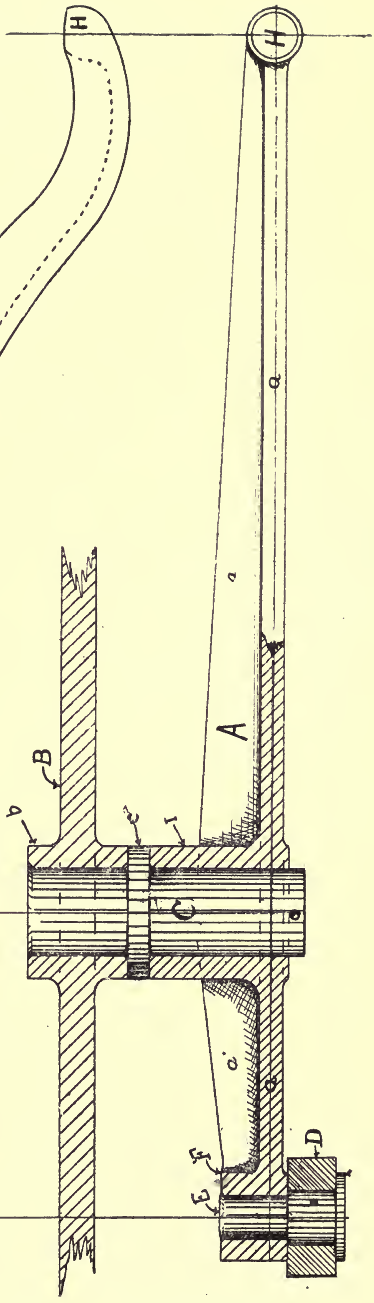


Fig. 40. Plan—Part Section.

learn before his friends see him flying (I say flying, because all tyros are going to fly—when their machine is finished!) up and down the streets in his motor vehicle.

Another point. If a manufacturer of a vehicle does a thing a certain way, and you, the would-be builder, think it is the wrong way, in fact, you are sure it is the wrong way, remember that your thinking so does not, unfortunately, make it so.

I do not mean, from the above, that experiments should not be tried, not by any means, but I do mean that there is a disease, a contagious disease, that grasps about all the motor vehicle tyros. The name of this malady is more expressive than euphonious, it is called "swelled head."

Investors want to be very careful of mechanics during the period when they are troubled with this malady, as its attacks are oftentimes very acute, but a sure cure is a year's work with their own motor vehicle. After the above prescription has been tried, the disease will be found to exist in a very mild form, if at all.

CHAPTER X.

Designing a Vehicle.

Now, regarding the right way to design a vehicle. Before any material is purchased with which to build a vehicle, the designer should select his motor, as this is the heart of the whole machine. If he has had no previous experience with motors of the type selected, he should get as early delivery as is possible, and after receiving the motor he should run it in the shop, starting, stopping and restarting. He should then, after mastering the particular machine, take it to pieces, examine all the parts, and then reassemble them and start and stop a few more times. By this time the designer will understand the motor he is dealing with.

After making a careful drawing of the outline of his motor, with its points of support, for attachment to the frame, he will be ready to design the vehicle, and this will require his careful attention, as a well-designed frame adds life to the vehicle and insures safety to the occupants. In the design of the frame, and in fact in all parts, he will be wise who will use such forgings and accessories as may be procured of manufacturers already equipped to supply such parts.

The next point to settle will be the transmission gear, and this part of the vehicle will require careful attention and should be worked along with the frame, as a policy of give and take will have to be adopted in order to properly arrive at a good truck, having a well placed motor, a good transmission gear and the whole carried upon a strong, well-designed frame.

After the running gear has been designed, as outlined above, the various controlling levers next demand attention, and in the arrangement of these there is ample chance to vent all one's ability, as the various combinations and positions of the governing handles is a really important feature and the designer who can, with the simplest mechanism, relieve the mind of the motorist to the greatest extent, by well controlling his machine with a minimum of motions, has accomplished something of value to the purchaser.

After the truck and controlling mechanism have been thoroughly worked out in the draughting room, the material for its construction may be ordered and work begun, but not before. While the work in the shop is proceeding the draughtsman may tackle the least important point in the whole vehicle, viz.: the body. The construction and the design of this latter are immaterial. A good looking body adds a selling value to a vehicle, but a good running carriage adds a greater value.

To sum up in a few words:

1. Make everything give way to the motor, and have a good motor before spending time or money on other parts.

2. Make everything (except the motor) give way to your transmission gear and frame.

3. Make your controlling levers fit your motor, frame and transmission gear.

4. Build your body around what you already have built.

Points to be remembered: A motor vehicle is a machine. A motor vehicle is not a bicycle. A motor vehicle is not a buggy. The motor vehicle is the coming means of travel for all, and those who build moderately speeded, thoroughly reliable and well built machines of long life, due solely to good work and design, will in time have their reward; and those who will abide by common sense, simplicity, and not be swayed by public opinion into building complicated and fancy toys, will be the ones who will remain in the business when the public have settled down to buy motor vehicles to use, and for use alone.

THE WRONG WAY TO DESIGN A VEHICLE.

A gentleman in the eastern part of Massachusetts, who has had a long and varied machine shop experience, and who has at the present time the business management of quite a large manufacturing concern, thought he would build a motor vehicle primarily for his own use, but with the object of manufacturing the same, should it prove satisfactory. Now, this gentleman had ideas of his own about a transmission gear and about other parts of a vehicle, such as the frame, controlling levers, etc., but unfortunately he had no experience with gasolene motors of any sort, and as a result thought that he could get a motor easily enough that would fit his vehicle when the latter should have reached such a stage as to be ready for the motor equipment.

Carrying these ideas out in practice, he first made up his mind what sort of frame would best suit his transmission, then he decided the best way in which to apply his transmission. Having settled these points in his mind, and after making careful drawings of these parts, he began the building of the vehicle. Naturally enough, things went swimmingly, and in a very short short time the running gear and transmission were complete. The next thing was to get a motor. And another natural thing was to pick out the smallest and lightest motor that it was claimed could drive his vehicle. This was procured and attached to the frame, about the middle of last September. Sometime about the first of January, not having succeeded in getting a respectable ride out of his vehicle, the gentleman in question purchased another motor, which he had seen at the motor vehicle show in New York. Having tinkered up his frame to suit the new motor he again prepared for a ride.

Now, this gentleman at this time knew of a good motor that he might have used, and probably without any experimenting, but because the cost of changing his frame was considerable, and because he had already spent something over $2,000 on his vehicle (which was a light runabout) he decided to patch up his frame, as we have said, so as to use a motor of doubted efficiency. The result is that the second motor is still on the vehicle, but the gentleman in question has yet failed to have anything like a good ride out of his machine. This is the wrong way, therefore, to build a vehicle.

The transmission gear is an important piece of mechanism. The frame is an important matter. But the motor is the important thing of all. And for this reason, as we stated before, the frame, the transmission gear, the controlling levers, the body, and, in fact, everything, must give place to the motor, and not the motor give way to any pet notions one may have about the other less important parts of a vehicle.

It may not be out of place right here to give another anecdote about a man who will probably have more success with his vehicle than the man above mentioned. This story, like the other one, is true, and the interested party is also one with whom the writer is personally familiar. The gentleman in the present instance has had several years' experience with gasolene motors out in Minneapolis, and he is also a mechanic of considerable experience. In company with some of his friends, he decided to build motor vehicles, and wisely decided to use such parts as he could obtain on the market, realizing that unless he had unlimited capital and very much more experience than he had already had it would be useless for him to attempt to build the whole vehicle. He therefore made out a list of all the motor manufacturers and makers of running gears and other parts there are in existence between Milwaukee and the Atlantic.

Having gotten his list as perfect as he could make it, he left Milwaukee on a personal tour of inspection to see and to learn. He visited every manufacturer he could find, and when in Boston the writer had the pleasure of meeting him, and knows that he has selected a good motor and one he saw tested on the road. He has also picked out certain forgings, made by a prominent concern, that he intends to use in his vehicle. Having selected these parts, and we believe having done something along the line of a vehicle frame, he has returned home in a position to do something in the way of turning out a good vehicle, and he has secured a fund of information that he could have gotten in no other way so quickly and so cheaply. From the systematic way in which this man has taken hold of the business, we believe that he will make an immediate success.

STANDARDIZING MOTOR VEHICLE PARTS.

It seems to us, as a result of our experience, that there are several things about a motor vehicle that may be standardized at present. Or if they cannot be actually standardized, they can be reduced to within very narrow limits, thus allowing manufacturers to carry a lesser variety but greater quantity of goods, and naturally if the variety is less the quality should be better. The points we refer to are, the diameter, for instance, of the wheels of a motor vehicle. Small wheels are light and may run faster, therefore necessitating less reducing gear than larger wheels require. On the other hand, larger wheels ride very much easier than small ones. In fact, one would not realize the difference without making the actual experiment, as the writer has done, but the large wheel is expensive, due materially to the increased diameter of the rubber tire. It is also heavy and requires more and heavier reducing gear between itself and the motor. But comfort is a great point on a vehicle, and must not be ignored, neither must the extra life of the machinery (due to the large wheels) be forgotten. Can we then not strike an average between the much used 28-inch wheel and the larger 36 and 41-inch wheels, and use a 32-inch wheel? This is what we shall use, and it is what a number of our friends have also decided to adopt.

If manufacturers will adopt a 32-inch or 34-inch wheel as standard, using all four wheels of the same size, then the tire makers can supply us with better tires than we get at present, and at considerably reduced prices, because they will save thousands of dollars in moulds and will be able, as well, to manufacture in large quantities. At the same time, they can simplify their catalogues and reduce their clerical force. Another point that may be reduced down to much narrower limits than at present, is the diameter of the cross section for the tire, for instance, a tire with a 2-inch cross section is too small for motor vehicle use. A tire of 2 1-2 inch cross section is good and not too high in price. A tire of 3-inch cross section is still better, but costs more, while a 4-inch tire is too expensive. If manufacturers of vehicles will only adopt these sizes, or will adopt some other sizes, it will be to their immense advantage, because, as we have previously stated, they will get better goods at better prices, and, what is more important, local agents will then be able to supply tires out of stock.

CHAPTER XI

Motor Construction.

In figure 41, we show the drawings of the piston of our motor. The following description, together with the drawings of the piston, will be all that is required to a complete understanding of this part. The first view shows a plan of the piston, half in section and half in elevation. The view clearly shows the wrist pin of the piston, which is preferably made either of tool steel (not hardened) or of a piece of machinery steel (case hardened). Our second view shows a sectional elevation of the piston, in which the grooves for the piston rings are plainly shown, and one of the bosses for taking the wrist pin may also be seen. The end view plainly shows the appearance of the piston, looking from the open end. This view shows in elevation both of the bosses for the wrist pin. The views showing the rings are self-explanatory.

In order to have a tight piston the mechanical work should be of the very best, and great care should be taken: first, to have the piston round; second, to have it of equal diameter throughout its length, and, third, (the most important point of all), to have the sides of the grooves for the rings parallel to each other and at right angles to the face of the piston. The piston should be made of rather hard cast iron. The important point about the rings is to have the sides of the rings parallel, and of just sufficient width to fit closely but not tightly in their respective grooves in the piston.

Another point to remember in machining the piston, is to have the wrist pin at right angles with the face of the piston, and to square off the bosses that carry the wrist pin, so that their inner faces (shown in the end view) will be equi-distant from the center line, in order that when the connecting rod is placed between them it will be central with the outside walls of the piston, and at the same time will lie parallel with the said walls.

The rings had better be made of a good hard cast iron, free from flaws. They may be pressed in the grooves in the piston by carefully stretching over the full diameter of the piston and sliding them down the piston to their respective grooves, when they will snap into place. Every care should be used in this operation to prevent the breaking of the rings, due to the considerable amount they have to stretch. An experienced hand, however, can snap the ring into place without losing more than one or two in a hundred.

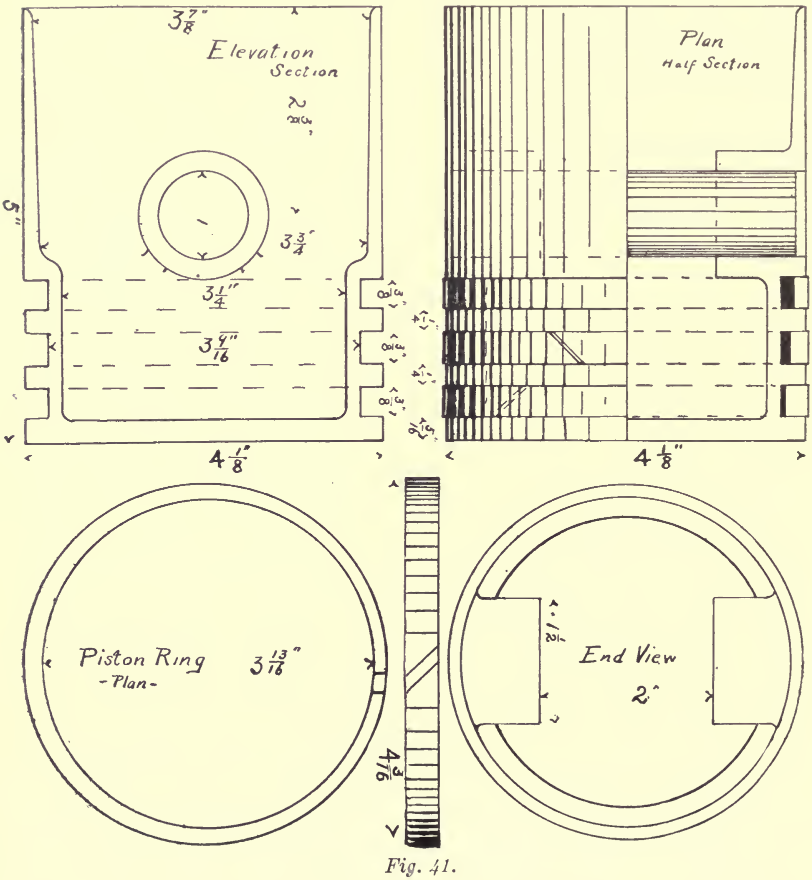


Fig. 41.

ELEVATION AND PLAN OF THE CONNECTING ROD FOR MOTOR.

The following short description will suffice to enable the mechanic to thoroughly comprehend its construction. The connecting rod proper should be made of a steel casting, or of a good malleable iron casting, while the box and the cap (which encircle the crank wrist) should be made of phosphor bronze or some other good tough bronze. Great care should be taken to have the one-inch hole in the piston end of the connecting rod at right angles to the center line of the rod, and to square off the ends of this boss so that they will be equi-distant from the center line. The flat surface, on the other end of the rod, abutting the crank box, should be machined square with the one-inch hole in the piston end of the rod.

The same precautions should be taken in machining the bronze box; viz., the 1 1-2-inch hole should be bored true with the face contacting with the connecting rod, and the ends of the box should be squared equi-distant from the center line, and narrow enough to allow of slight play between the cheeks of the crank. The bolts holding the cap in position, should be turned from the rod, and are supposed to be 5-16-inch diameter. They should be furnished with a nut and a check nut, and if it is desired to make assurance doubly sure, a split pin may be put in in front of the check nut, to keep the latter from falling off, should it ever come loose.

If the above directions are carefully followed in machining the connection rod, and if the piston has been properly made (according to our directions) it will be found, when the connecting rod is put in place, and the wrist pin of the piston is passed through the walls of the latter, and through the one-inch hole in the connecting rod, that the crank box will be central with the piston.

The crank is clearly shown in figure 43 both in plan and in end view.

A crank of this sort is necessarily an expensive part of the machine, especially if it is made from a forging, which is undoubtedly the best way. A pattern, however, may be made and from this a steel casting, which, when machined up, will make a fairly good crank. But on account of the

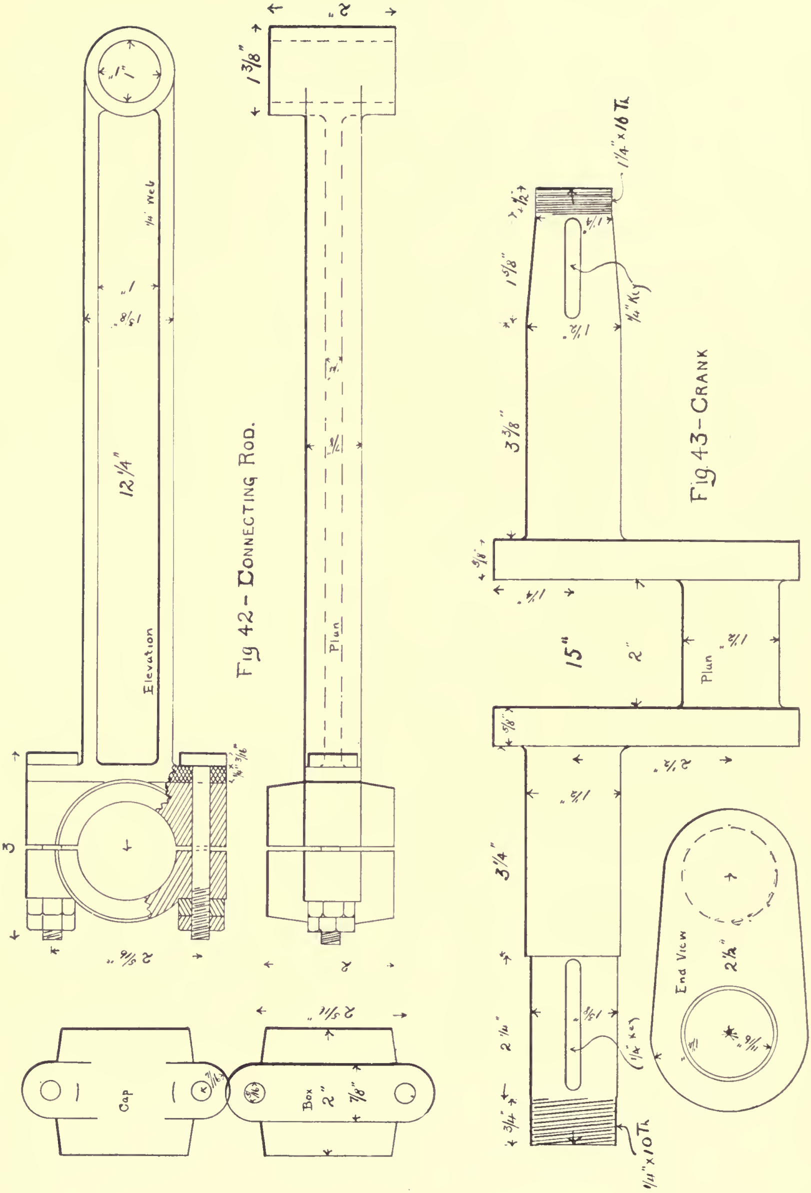


Fig 42 - Connecting Rod.

Fig. 43 - Crank

blow-holes, which almost invariably accompany such castings, the builder cannot have the same feeling of security, when using such a crank as he would have with a forged one. This is especially true, seeing that the blow-holes usually occur at the junction of the comparatively heavy shafts or wrists and the light webs of the crank. The cause is the unequal cooling of the casting, and for this reason the holes are usually located below the surface of the casting, and near the center of the crank.

If steel castings are debarred, for the above mentioned reason, the cheapest remaining way to obtain a thoroughly reliable crank is to get a piece of steel large enough to make the center part of the crank (as shown in the end view) and from this piece of steel draw down crank shafts slightly longer than shown in the drawing. This will leave a solid chunk of metal, between the crank cheeks, that can be removed by drilling a series of holes across where the wrist is to be and sawing down the two inside faces of the crank, far enough to meet the drilled holes. In this way the bulk of the metal will be removed. That remaining will have to be machined off in the lathe. To do this centers should be made in the ends of the crank shafts and the latter roughened out to about 1-8-inch larger than the size shown.

While the crank is in the lathe the outside of the webs may be made true, and if only one crank is to be produced a segment of a circle with a 2 1-2-inch radius may be described on the outside surfaces of the webs, with the lathe tool. The crank may be now taken out of the lathe and centers made in the webs on which to turn the wrist. These centers will, of course, be midway in the width of the crank face, and within the segment of the circle just mentioned. If this is carefully done and the wrist is turned on long centers, it will be parallel and in the same plane with the crank shafts. After the wrist is turned to size, the crank shaft may again be placed on the original centers and the two shafts turned down to the sizes given. A distance piece should be placed between the cheeks of the crank on this last cut, so that tightening up the centers will not spring the shaft. A crank made in this way will stand an almost unlimited amount of banging around.

In figure 44 we have shown a vertical section and an end view of the cylinder used in our motor, and in figure 45 a plan section and end view of the exhaust and inlet valves.

The illustrations are self-explanatory, as far as dimensions go, but the following general directions will probably aid the amateur materially in machining the parts.

Let us first consider the cylinder. Preferably, this should be made of a good hard cast iron, of the same metal as the piston is made of, and sufficient metal should be allowed on the inside wall of the cylinder so that when it is completely machined all surface imperfections in the casting will have disappeared. Probably the best way for the average mechanic to machine such a cylinder as this will be to clamp it to the saddle of a lathe and then bore it out with a boring bar running on centers. In the event of machining it in this manner, it would be better to support the casting by the two flanges that act as water jacket ends, for in this manner of holding it there will be less liability of drawing the cylinder out of shape. This is a matter that should be given great care because if the cylinder is cramped while being turned it will be sure to spring out of true when released from the clamps. In boring out there should be at least two cuts taken, and if a "bang-up" job is desired a third light cut should be taken.

Having now machined the interior wall of the cylinder, it would be better, before going further, to obtain the tube that is to form the outside wall of the water jacket. This had best be made of a steel, but a brass tube can be made to go by taking care with the joints. The reason we give preference to a steel tube is because the ratios of expansion of steel and cast iron are nearly alike for the temperatures which the joint has to withstand; whereas, the ratio of expansion of the brass tube is higher than that of the cast iron cylinder, therefore, it expands more on being heated than does the cast iron, and for this reason is more liable to leak at the joint.

The tube shown is 14 gauge, although a somewhat lighter or heavier tube may be used. In order that proper pipe connections may be made to such a thin tube we have shown two nipples which (in the case of the steel tube) are made

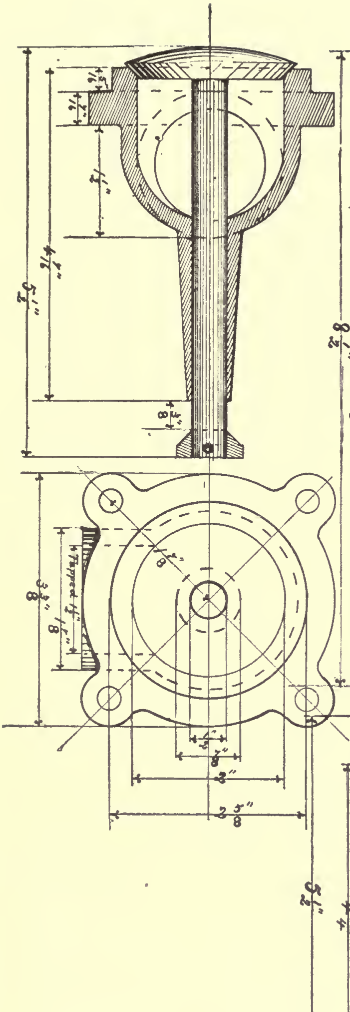


Fig. 45.

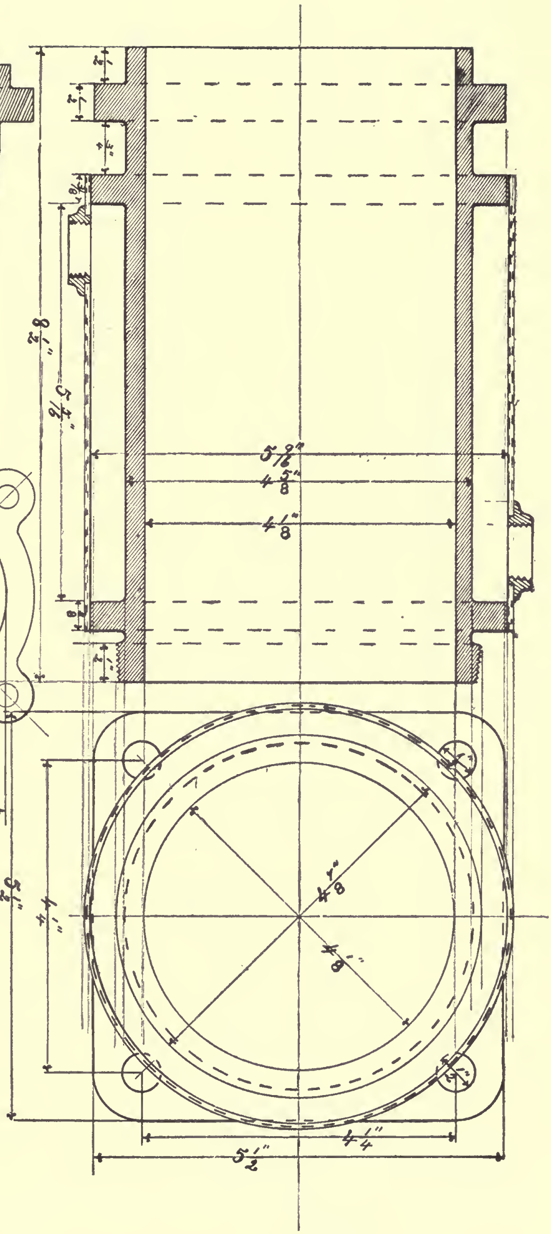


Fig. 44.

of steel and brazed into the jacket tube, in the relative positions shown. But if a brass tube is used these nipples should be also made of brass or other composition and soldered with hard solder into the jacket tube. Whichever construction is followed, the inside of the jacket tube should be filed smooth so as not to interfere with placing the jacket tube over the flanges of the cylinder.

Having reached this stage, we will now take the cylinder, and, placing it upon an arbor, will be ready to cut the thread on the combustion chamber end, and also face up the flange used for bolting the cylinder to the crank case. After having done this, the two flanges over which the water jacket tube is to be fitted, will next demand our attention. These should be turned off about 1-100-inch in diameter larger than the inside diameter of the tube that is to be fitted to them. It is well to remember that in measuring the inside diameter of the tube that the measurement should be made in several places, and each end of the tube should be measured independently because these steel tubes vary slightly.

After the flanges have been turned off according to the above directions we shall be ready to place the tube into position. This can be best done by heating the tube slightly over a fire and when it is hot it may be placed in position by sliding it over the cylinder flanges. This must be quickly done before the tube cools off or else it will be likely to stick. The thread on the combustion chamber end of the cylinder is preferably of sixteen pitch, and is cut slightly tapering, so that a tight joint may be made with the combustion chamber.

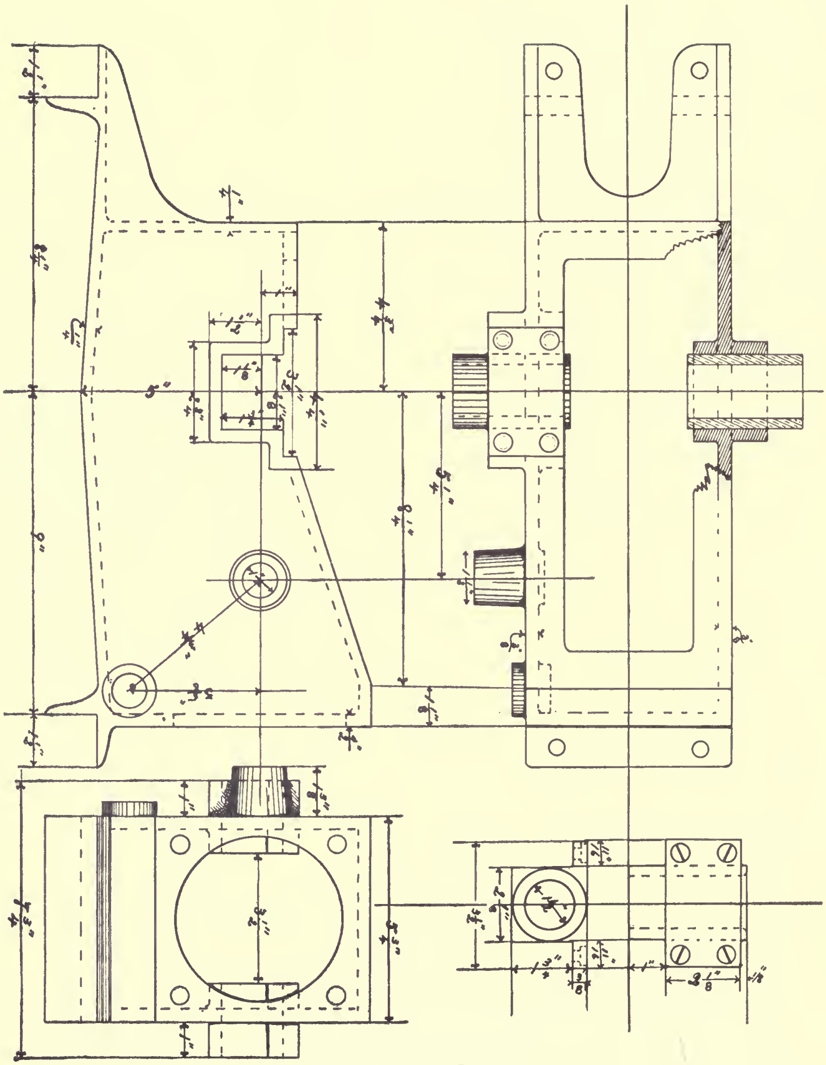
We have shown in figure 45 only one set of drawings for both the exhaust and the inlet valve because by making them of the same size considerable labor will be saved. The outside casings of the valves are made of cast iron, as are preferably the valve heads, and the spindles are made of steel. Those ends of the spindles passing through the valve heads should be somewhat reduced and the valve heads driven on, leaving about an 1-8-inch sticking through the heads. This should be well riveted over. On the other ends of the valve stems are conical washers which serve for the springs, holding the valves closed, to bear against. These washers should be tight fits, and pinned on as shown. It will, of course, be understood that the valve heads and stems should be turned on centers, after the heads are riveted on the stems. Also that the valve seats should be bored out on arbors passing through the holes of the casings in which valve spindles work.

If these directions are followed, a good job will result. The spring holding the exhaust valve closed should be wound up of about 10 gauge best spring wire, and should be of sufficient length to require a pressure of from twelve to fifteen pounds to open the valve. The inlet valve spring should be wound of 18 gauge piano wire, and the valve should require about three-fourths of a pound pressure to open it.

In figure 46 is shown a plan, elevation and end view of the crank case or base for our motor. This case can be made of either cast iron or of aluminum. If made of the latter metal, it will weigh about fifteen pounds less than if made of cast iron, and further, because of the softness of the aluminum, it will be necessary to exercise considerable care in holding the case while it is being machined, so as to not crush it. It will also be necessary to bush the cam shaft bearing, if the case is of aluminum, with a composition bushing. If a cast iron case is used this precaution is unnecessary.

The following general hints may be useful in machining this part of the motor:

In order to get proper alignment of the parts, it is better to first plane the two feet which serve to attach the motor to the frame of the vehicle. After having done this, the bolt holes should be drilled. If the feet of the crank case are now placed on parallels upon the bed of the planer, so that the case is in a position crosswise to the bed of the planer, with its center line exactly at right angles to the bed, we shall be in position to plane out the recesses for the crank shaft composition boxes. Having carefully planed these recesses to the given dimensions, the planing tool should be shifted to the cylinder end of the case, and this end planed true. By doing all of this planing without shifting the case, we stand a good chance of having the crank bear-



Figs. 46 and 47.

ings and cylinder at right angles. The hole for the cam shaft, as well as the hole for the exhaust lever stud, demand no particular attention. The hole in the end of the case, however, which admits the end of the cylinder, should not only be bored to well fit the end of the cylinder, but it should also be central with the crank case.

In figure 47 is shown two views of the composition crank boxes. These should be made of good, tough gun metal, and had best be machined as follows. First bore and ream the 1 1-2-inch holes for the crank. Then place the box on an arbor, and either plane or mill the surfaces to fit the crank

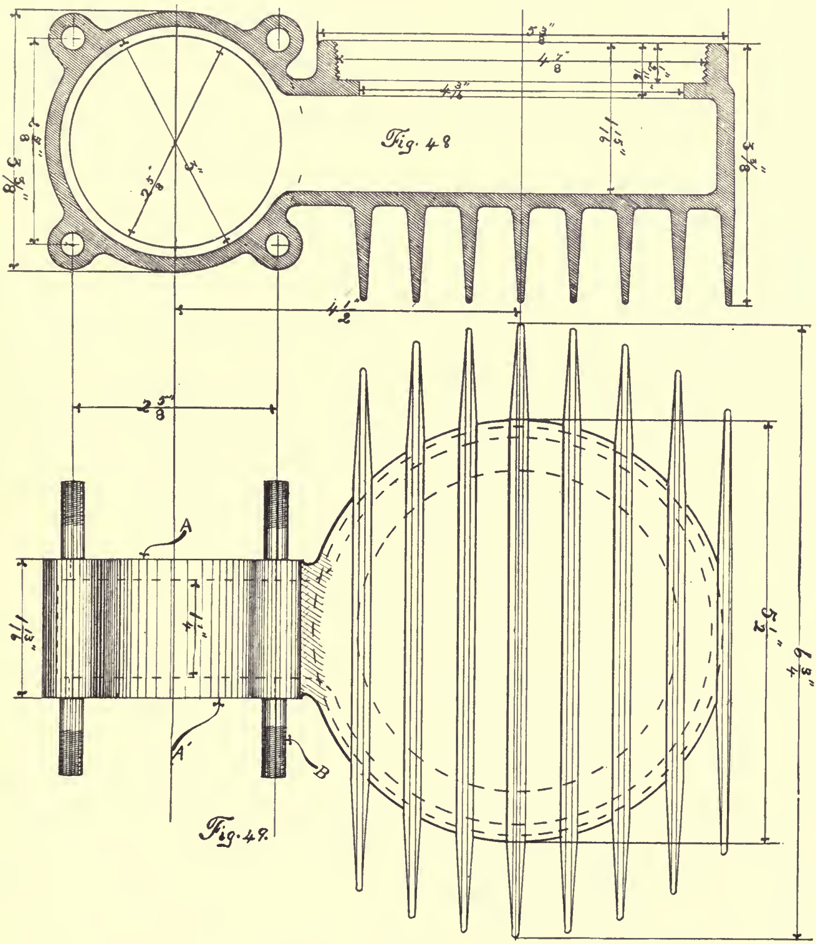


Fig. 48

Fig. 49.

case. While machining these surfaces it would be best to hold the arbor on centers, for in this way a true job is insured. While the box is on the arbor, the end faces should be squared.

In figure 48 is shown a plan section, and in figure 49 an elevation, of the combustion chamber of our motor. In making up the pattern, it will be necessary to have a very good finish on the radiating ribs in order that they may lift smoothly from the sand. A better job will probably be secured by casting the combustion chamber in the position shown in the elevation, in which case, of course, the ribs should come in the nowel. The only part of the machine work requiring special care is to have the thread that fits the cylinder end a good fit on the cylinder. It should be made with a very slight taper and should fit tight. All sharp corners within the combustion chamber should be very carefully removed before finally screwing it to the cylinder. The two surfaces, A and A′, should be carefully machined so that a tight joint will be made when the inlet and exhaust valves are placed in position. A thin sheet of good asbestos paper, soaked in linseed oil, should be used as packing between the valves and the combustion chamber. The studs, B, for attaching the valves pass right through the ears on the valve chamber, so that the single set of studs serves for both valves. These studs should be a sufficiently tight fit in the ears on the valve chamber, so that when the top, or inlet valve, is removed the lower, or exhaust valve, will stay in position. These studs could, of course, be tinned in the ears, if desired.

EXHAUST AND SPARKING CAMS.

The exhaust cam and its shaft are made in one piece, as shown in figure 50, of either a steel casting or a steel forging, which should be turned up at B so as to tightly fit the hole in the cam shaft gear, while at A it should be made a close fit for the spark cam, 53. The rest of the shaft should be a running fit in the box provided for it on the crank case. The inner, or free, end of the cam shaft, after being squared off to the proper length to fit its box, should be drilled and tapped for a screw, D, as shown in figure 51. This screw

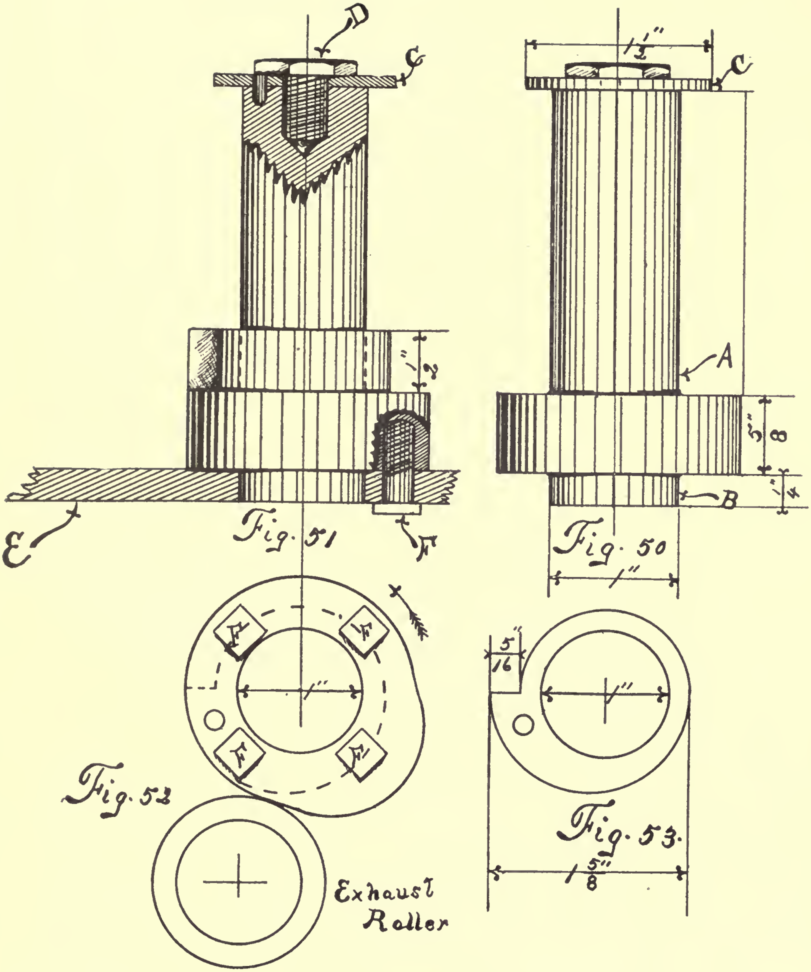


Fig. 51

Fig. 50

Fig. 52

Fig. 53.

will serve to hold in place the steel washer, C, which is kept from rotating by the small steady pin shown. The cam shaft gear (a portion of which is shown at E) is held in place on the cam shaft by the cap screws, F, as shown in figures 51 and 52.

The shape of the exhaust cam should be such as to give an easy entry on opening the exhaust valve, while on closing it may be slightly more abrupt. The height of the cam should be sufficient to raise the valve 3-8-inch, while its length should be such as to begin to open the valve just before the piston reaches the outward end of the stroke, and to hold the valve open throughout the exhaust stroke and allow it to close just after the crank has turned the inner dead center. This result will be accomplished if the cam occupies a little over one-quarter of a circumference, as shown in the drawing, figure 52.

The sparking cam, figure 53, should be placed so as to cause the spark to take place just previous to the crank reaching the inward dead center, or slightly before the compression is completed. The position is shown in figure 52, by dotted lines, where it will be seen that the fall of the cam is diametrically opposite the entrance of the exhaust cam. If the spark cam is placed in this position, and the engine put together and turned by hand, the cam can then be located to a nicety. After having done this the cam shaft can be removed and the spark cam pinned to the exhaust cam by a steady pin, as shown. The cam shaft should be again replaced, care being taken to have the exhaust and spark cam properly placed. This can, of course, be accomplished by properly meshing the teeth of the cam shaft gear with the gear on the crank shaft. When this is done the meshing teeth of the gears should be prick-punched, so as to save time in putting the engine together thereafter.

The cams as shown in figure 52, are set for the engine to run under. If it is desired to run the motor the other way, the spark cam should be turned the other side around, and its drop moved diametrically opposite the then entering side of the exhaust cam.

CHAPTER XII

Mounting a Motor in a Vehicle.

Considering gasolene vehicles alone, there are three distinct designs of machines: First, those having the motor and mechanism mounted within the carriage body, and upon the springs of the vehicle; second, those in which the motor and other mechanism is mounted upon the truck of the vehicle, and having no positive connection with the body; third, those in which the motor and other mechanism is mounted on one set of springs while the body is mounted upon an entirely independent set. Let us consider each form of design in detail:

The practice of mounting the motor within the body of the vehicle, or upon the same springs as the vehicle body, was adopted by all the early designers of practical vehicles. There were two distinct types of this design. In the first, originated by Benz, of Mannheim, Germany, the motor and all the transmission gearing was mounted under the seat and within the body of the vehicle, in such a way as to be entirely out of sight. In this form of vehicle it was necessary to have some flexible connection between the transmission gear (within the body) and the driving wheels of the vehicle, in order that the springs might have the necessary freedom to act. This flexible connection was obtained by the use of two sprocket chains, one to each of the rear driving wheels. The distance between the centers of the sprocket wheels was in some cases maintained by radius rods, which forced the springs to act in an arc rather than in a vertical plane. In other designs the radius rods were omitted and the springs made so stiff that the sprocket chain would seldom jump the teeth.

In the second type of design under consideration, the motor was mounted in front of the body proper, and upon the same springs, or in about the same position that is usually occupied by the dasher. This type of vehicle was originated by Daimler, of Cannstatt, Germany, and is the form adopted by the celebrated French firm of Panhard & Levassor, who have built all of the fastest and most powerful machines yet constructed. (This firm built the celebrated machine on which Charron, in 1900, won the Gordon-Bennett cup.)

This construction has one material advantage over the other, in that the passengers sit well over the rear springs of the vehicle, while the motor is mounted on a rather stiff pair of springs at the other extreme of the vehicle body. As the body is long, it will be seen that the stiff springs in front do not materially jar the passengers, because they are sitting over the flexible springs in the rear of the vehicle and because the long body has a hinge action on the front stiff springs. The advantage of making the front springs very stiff is that it prevents the vehicle from jumping very much, when traveling over uneven roads. This makes it easier to connect between the spring-supported body and the driving wheels, while there is still flexibility enough to relieve the motor from undue road strains. In vehicles of this class, the power is usually transmitted to the driving wheels by chains, one to each of the rear wheels, the chains, as before, allowing for the motion of the body.

VEHICLES IN WHICH THE MOTOR AND OTHER MECHANISM IS CARRIED ON THE TRUCK.

There have been a great many attempts in the design of motor vehicles to so isolate the mechanism from the body, or that portion of the body on which the passengers sit, that riding in the vehicle would be as comfortable, if not more so, than it would be in the best designed horse drawn vehicles. The motive mechanism has been mounted on a separate or bogie truck, the latter being connected to the running gear proper of the vehicle by some form of flexible connection, in this way eliminating all of the vibration or jar, due to the motor or driving mechanism. The bogie method, however, is of little interest to us because of its great expense, and also on account of the difficulty of guiding and controlling it.

The other attempts to relieve the body from vibration have usually consisted in mounting the motor and driving mechanism rigidly on the connecting members between the front and rear axles, the motor being placed either vertically or horizontally, in accordance with the opinion of its designers. For light carriages we certainly prefer the horizontal method, because the wheels being free to turn on their respective axles, give the motor freedom in its vibration. Being free to vibrate the truck, the motor, at certain speeds, will vibrate it excessively, but there are other speeds, that may be ascertained by experiment, at which the vibrations of the motor are "out of phase" with those of the vehicle. When under these conditions, the truck will vibrate but slightly. On the other hand, when the motor is placed vertically in a light vehicle (the writer has had no actual experience with vertical motors, mounted rigidly upon the truck of heavy vehicles), the resiliency of the tires causes an excessive vibration, which is more annoying when the tires are hard blown than when they are soft—it being understood that we are considering pneumatic tired vehicles.

The following experience of a vertically mounted motor, which occurred on an experimental vehicle with which the writer was working, will serve to illustrate this point of vibration. An engine, of about 4-inch stroke, was mounted vertically upon a peculiar form of rear axle, to which the motor was rigidly attached. The wheels of this vehicle were shod with three-inch pneumatic tires, and the whole truck, motor, axles and wheels, weighed about 700 pounds. On starting the motor the whole truck began an up and down vibratory movement and as the engine gathered speed the movement of the truck became more rapid in its endeavor to remain synchronious with the motor vibrations. Gradually the frame began to jump higher and higher, until it would jump perhaps two and one-half inches from the floor. When this point was reached, the time taken in the vibrations of the truck was too great to allow it to follow the vibrations of the motor, and as a result there would be, for a moment, a total cessation of vibration, due to the fact that the motor and truck were out of phase with each other. In the course of a couple of seconds the truck would begin as it had on former occasions, the whole series of operations being repeated.

It will be understood that when the motor is placed horizontally, there is a to and fro rocking motion of the truck on the wheels. But there is no elastic medium to cause a rapid reaction, such as is caused by the pneumatic tire. Hence, the motor speed is nearly always too fast for the heavy frame to follow its vibrations. For this reason, there is little vibration, as a general rule, and this little is seldom transmitted to the body, on account of the isolation of the latter from the truck, through the medium of the springs. And thus while the truck may oscillate in a horizontal direction to quite a perceptible extent, the body will remain stationary, or practically so, because the springs cannot move the body back and forth fast enough for the truck. On the other hand, if the truck has a vertical vibratory movement, the elasticity of the springs will act somewhat as does the flexibility of the tires, causing (at low speeds) a very objectionable jumping of the body.

VEHICLES 'N WHICH THE DRIVING MECHANISM IS MOUNTED ON INDEPENDENT SPRINGS.

There have been a number of vehicles built, from time to time, on the above lines, viz., in which the driving mechanism is mounted on independent springs, but to the best of our knowledge these vehicles have been never perfect enough to be placed on the market, as we do not call to mind, at the present moment, any manufacturer using this method of suspension. We presume that the trouble with this practice is largely due to the difficulty of controlling the motor, clutches, etc., when the levers for operating these parts are carried by the body, which is on one set of springs, while the motor mechanism is on an independent, and therefore independently moving set of springs.

In deciding which of the above described methods to adopt in mounting the motor and other mechanism in a vehicle, it is necessary for the designer to have some fixed idea as to what is the most important consideration. We mean by this that the designer must be certain in his own mind whether he is trying to build a vehicle where comfort is to be paramount, or if he wants a vehicle in which durability is to be the primary object sought. He may just as well make up his mind first as last that he cannot design a vehicle to give passengers the maximum of comfort and at the same time mount the mechanism as he would had he not the passengers to consider. The whole design of the vehicle, as we have before pointed out, is a series of compromises. For ourselves, we consider the comfort of the passengers the all-important feature in a motor vehicle, and for this reason we consider that the practice of mounting the motor and other mechanism on the truck makes a better all round vehicle than either of the other constructions mentioned. It is this design which we shall describe.

Another important point in the design of a vehicle is whether or not the machinery should be covered so as to hide it from view. There is a tendency among builders to follow this plan, as if they were ashamed of the machinery and wished to cover it so that it may not be seen. On the other hand, some manufacturers are afraid that some other fellow will learn something, and so they distort their mechanism and crowd it so as to get it out of sight. This is an unwise thing to do, as the old proverb: "Out of sight, out of mind," was never more true than in its application to motor vehicles, and manufacturers that make machines of which they are proud should aim at keeping the mechanism in sight, where the operator can see as much of the working parts as can be exposed. In this way he will often see small things that need attention before they give out or cause trouble, and of course prevention is always better than cure.

It seems foolish, to the author, to cover up a nice piece of machinery as it would be to cover a good horse so as to hide the animal from view, or as it would be for a cyclist to throw a cloth over his bicycle with the object of making people believe that some mysterious agent was propelling the wheel. When we speak of not covering the machinery, we do not mean to go to the extent of eliminating gear cases, mud guards, etc., where necessary, but we do mean to have as much of the motor and its driving mechanism in sight as is consistent with road conditions. If purchasers would favor such machines as this they would certainly get better workmanship, because every manufacturer takes more care when building machinery that is to be exposed than with that which is hidden from view.

GENERAL LINES UPON WHICH THE FRAME CAN BE BEST BUILT.

In a frame such as we are considering, the main points to be aimed at are as follows: First, a structure that will serve to hold the front and rear axles in proper relationship to each other while at the same time it will allow any one of the wheels a vertical movement, practically independent of the other three, but will not allow any lateral movement of the wheels. Second, our frame must act as the carrier for the motor and must be so constructed as to hold the motor in rigid relationship with the rear or driving axle. Third, accommodation must be provided in the frame for a suitable transmission gear which should be so mounted as to be easily accessible; it must also be rigidly supported in its relation with the motor and the rear or driving axle so that the various countershafts, motor shaft, and axle may not be strained out of proper alignment, either by the pull of the motor, or by the inequalities of the road surface. Fourth, a frame for the vehicle we are considering (for the amateur builder) should be so designed as to be easily built with few tools, at a low initial cost, and at the same time it must be durable and light in weight.

Before considering the material to be used in our frame, it will be necessary for us to decide what kind of tires our vehicle is to run upon, because the vibration of the motor is a sufficiently difficult problem to handle without having to consider road vibration, but if we have to design a frame to withstand excessive road vibrations as well, we shall have to use an entirely different construction than would be required were we to relieve the said road vibrations at the wheels.

This brings us to the very important point of wheels and tires. In considering the wheels we have two types to select from, viz.: wood wheels or wire wheels. In the question of tires we have to select between a metallic tire, a solid rubber tire or pneumatic tire, and in making our selection of tires we must consider the nature of road surfaces over which the vehicle is to run. For instance, if we are to run on a hard, level surface, a perfectly true wheel with a hard steel tire would be the most economical wheel to employ, and under these conditions a heavy wheel would be better than a light one, but on the other hand, if we are to run over rough surfaces and undulating roads a flexible tire and a light wheel are the best suited to our vehicle. As the latter described road is the one with which we are familiar, in this country, it is the only type of road surface that we are called upon to consider in this article. This being the case, we have to decide between a solid rubber tire and a pneumatic tire, as these are the only two types of flexible tires that have yet withstood the practical tests of the road.

At present, the choice of tires is a much mooted question among manufacturers, but the tendency of the times is clearly in favor of the pneumatic tire for the following reasons: Over average roads the pneumatic tire is easier riding; less wear and tear on the machine. And on bad roads, such as sandy, muddy or snow-covered streets, the pneumatic tire has not only more traction but a vehicle equipped with it is much easier driven, because of the large tire contact. The solid tire has the one advantage that it is puncture-proof, but we think that on ordinary dirt or macadam roads, as we find them in this country, the puncture trouble is often much exaggerated, if the vehicle is driven at reasonable speeds. We say this from experience, as we have used one set of tires, manufactured by one of our prominent tire companies, for over 1,200 miles without the slightest intimation of a puncture, and this driving has been done over all kinds of roads and considerable of it at night. Moreover, these tires were fitted to a three-wheeled machine, which, on account of needing three tracks probably subjected the tires to more severe trials than if the vehicle had been fitted with four wheels, in which case there would have been but two tracks. Considering the comparative freedom from puncture of good pneumatic tires, we much prefer tires of that type. As with the tires, the wheels should be selected with regard to the class of vehicle upon which they are to be used. For the general run of vehicles we prefer a wooden wheel, because it is more flexible, more easily repaired, more readily cleaned and more substantial looking, but for a light vehicle, such as the one under present consideration, we believe in the use of a wire wheel, because it is lighter in weight, considerably cheaper and more readily obtained. For these reasons, we shall use a wire wheel with pneumatic tire. Having decided the type of wheel and tire upon which our motor will be mounted, we will return to the material best suited to the construction of the frame.

It will be observed that we have made our frame construction dependent upon the class of wheels and tires used. We have been specific in this direction because the ill effects of road vibration seldom receive the consideration that they should do from motor vehicle builders, and hence accidents and breakages have frequently occurred, in parts that seemed heavy enough, that were due to the crystalization caused by this road vibration. It is a well known fact that cold drawn steel tubes are very subject to this crystalizing effect. In fact, ordinary wrought iron steam pipe will stand a much more severe vibratory test than will the best quality of steel tubing, while angle, I beam and channel sections, rolled and of mild steel or good quality iron, will stand a vibratory test better than any tube. And a combination of wood and iron, such as is used in the axles of an ordinary buggy, show up the best of all. However, when a light vehicle is being considered, and this vehicle is mounted on pneumatic tires of good size, a tubular steel frame will, if properly designed, stand a great deal of knocking around, and on account of the neat joints possible, the facility with which the tubing may be brazed and its pleasing effect to the eye, we think that this material is the best suited for our purpose.

ELEVATION AND PLAN OF THE FRONT AXLE.

In figures 54 and 55 we show an elevation and a plan of the front axle of the vehicle we are describing. The following general description will give an idea of the functions of this axle, the details of which we shall take up with enlarged drawings. It will be noticed, first, that this axle is composed of two flat steel bars, 3 feet 9 1-2 inches long, on centers, 1 1-4-inch wide, and 7-16-inch thick. They should

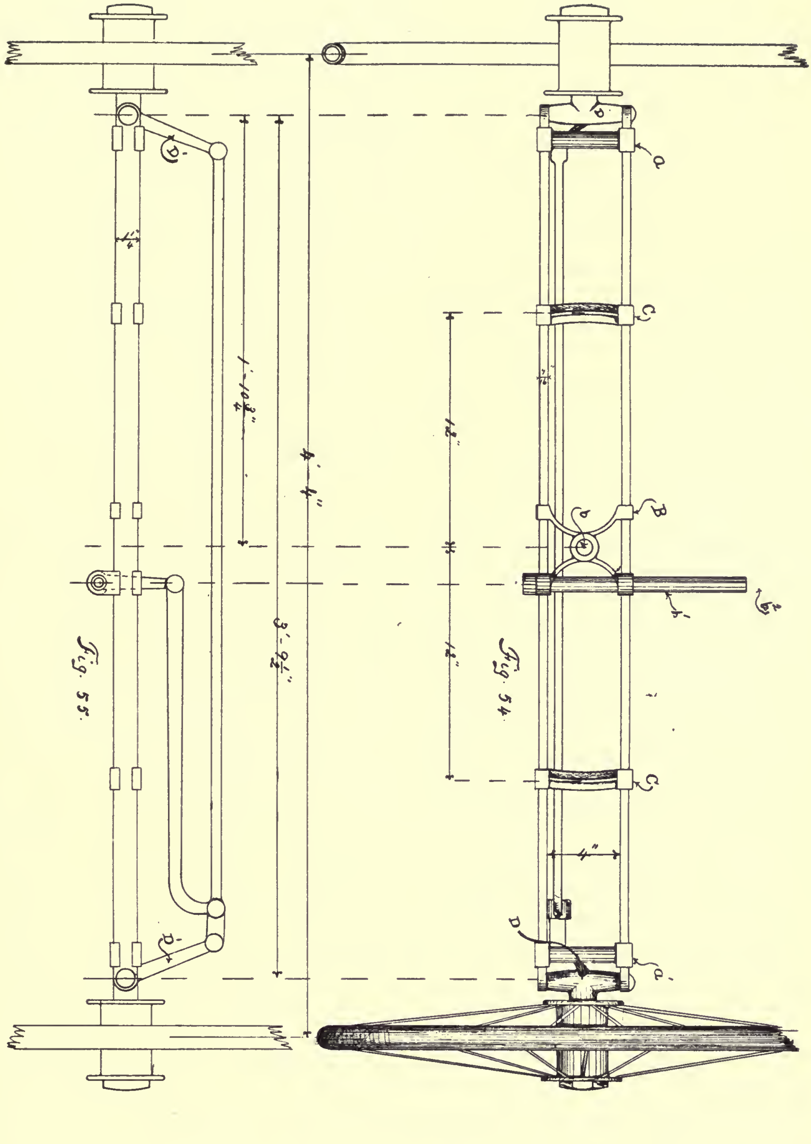


Fig. 55.

Fig. 54.

be of a good quality mild steel. The ends of the bars are rounded as shown, and by being prolonged beyond the distance pieces, a and a′, the bars form the supports for the swivel axles. This will be found to be a very handy construction for those having limited facilities. In the center of the axle is a light spider casting, B, which carries in its center, b, the swivel-pin of the frame which will be hereafter described, while at one side of the center is carried the steering tube, b′, through which the steering rod, b2, passes. At either side of this central casting and equi-distant from it are two thrust plates, c, which are curved on a radius from b. These thrust plates are finished on the sides facing the rear axle. They take the thrust or side strains from the swivel-pin, b, of the frame, by contacting with surfaces of the frame to be hereinafter shown. All these fixtures are chambered or grooved to slide on the two axle bars. When put in place, they should be held with small pins and brazed. It is to be understood that these fixtures should be made of a good quality of cast steel. Malleable iron may be used, but it is not recommended. The swivel axles, d, had best be made from drop forgings. There are several enterprising manufacturers at present offering forgings that can be used, at these points, by simply bending the steering arms, d′, downward, so as to come in the proper position. As has before been stated, it is well for those building vehicles to use such parts, in vehicle construction, as may be obtained from those manufacturers having the foresight and confidence to go to the necessary expense to supply such parts. In this way much expense is saved the builder, while at the same time he is encouraging the manufacturers indicated, who deserve it, and they are then willing to go to still further expense in getting out other desirable specialties. The swivel axles, d, are good examples of such specialties as we refer to.

MAKING A STRONG WHEEL.

The whole secret of making a strong wire or suspension wheel is to have, first, a good strong rim; second, a hub with large diameter flanges and considerable spread, or distance, between the flanges. Of course, it is necessary to have reasonably heavy spokes and a reasonably heavy hub, but the main point is the rim.

In figure 56, we show the style of hub the author is using in his own work. The outside casing is of a good quality steel casting, and it is counterbored at each end to receive a cup as shown in figure 59. These cups are pressed from the best quality tool steel and are carefully hardened, after which they should be ground with care both inside and outside, to the sizes given, and pressed into their respective positions in the hub casting. The dust cap shown on the end of the hub is preferably made of composition, and the bead should be knurled so that it may be screwed into place by hand. A fine screw thread (about No. 20) should used, as when fine threads are used there is less liability of losing the cap due to its unscrewing because of road vibration.

In figures 60 and 62, we show the right and the left front swivel axle in plain view, while in figure 61, we show an end view of the left-hand swivel axle, in which it will be noted there are two link-levers, shown, one in dotted lines, and the other in full lines. We have shown the dotted lines because that would be the preferable form of construction, but as forgings cannot be obtained of this pattern, to the best of our knowledge, it would be necessary to use steel castings or else the pieces would have to be forged by hand. The former method should be avoided, as castings should not be employed in the steering mechanism. In the latter method of hand forging the cost is considerable. We, therefore, prefer to use such forgings as may be obtained, and the link-levers may be bent, as shown in the full lines, so as to bring the steering link in the desired position. It is, of course, understood that the left-hand swixel axle, figure 60, is threaded with a left-hand thread—20 threads to the inch—while the right-hand axle, figure 62, is threaded with a right-hand thread. The drawing clearly shows this. In figure 58 we show the cones used. These should be turned up from a tool steel bar. They should be carefully hardened and ground. The cones that are on the inside, or next to the swivels have inch holes in them, while those at the threaded ends of the axles are threaded so as to be a close fit on their respective

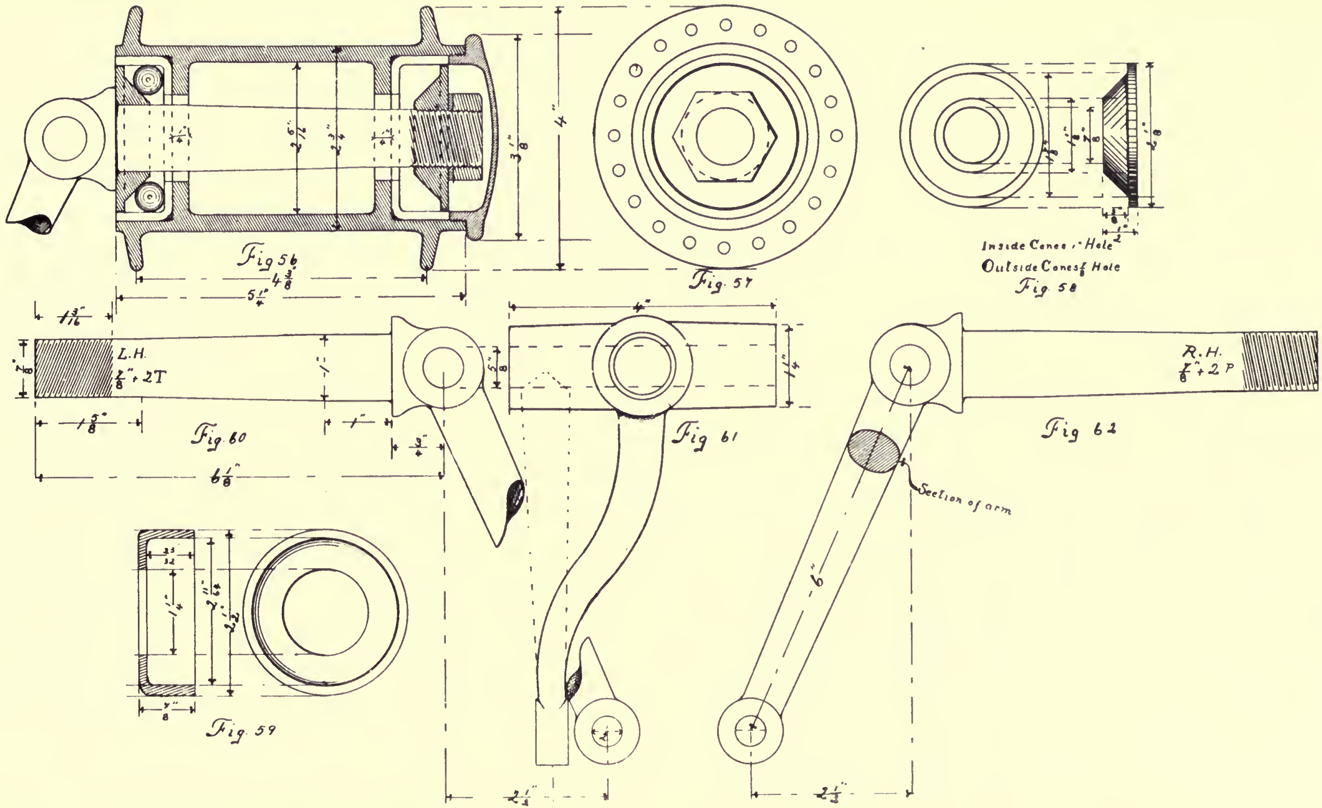


Fig 56
Fig. 57
Inside Cones 1" Hole
Outside Cones 5/8 Hole
Fig. 58
L.H.
7/8" + 2T
Fig. 60
Fig 61
R.H.
7/8" + 2P
Fig 62
Section of arm
Fig. 59

axles. A locking washer should be placed next to the threaded cone and the cone locked with a check nut, as shown.

After machining the hubs of our front wheels, and having drilled each of the flanges with 20 holes for No. 9 spokes, and counter-sunk the holes thus drilled so as not to leave a sharp corner to wear against the bend at the spoke head, we are ready to have the hub nickeled or enameled according to fancy.

The rims should also be finished before the wheels are assembled. They can be obtained from several firms, drilled with 40 holes for No. 9 spokes and punched with square holes to take the tire lugs now universally used with motor vehicle tires. Any size rim may be used, but we have shown a 32-inch by 2 1-2-inch wheel, which requires a rim 27 inches in diameter and about 2 1-4 inches wide. We prefer this size wheel for reasons given in a previous part of this series of articles. Before sending the rims to be enameled it is well to go over them and thoroughly clean off all grease with a little gasolene and to further file up any rough or scaly portions, as the enamelers seldom take due care in these matters, if left to them.

After the hubs and rims have been finished, the spokes should be threaded into place and the nipples screwed on, to their approximate place. The wheels should then be mounted upon a stud, the axles will do, in a convenient position, and trued up. This is best done by spinning them and holding a piece of chalk near the rim where it will mark the side running out. In this way the wheels may be made perfectly true.

We are now ready to apply the tires. The first thing to be done is to get some hard tire cement (care should be taken to select a good grade of cement, as there are many inferior grades offered) which should be slowly melted in a can, and when fairly fluid should be applied to the clean surface of the rim, with a stiff brush, and as evenly as possible. The operator must be careful to keep the cement from boiling over the sides of the can, as it burns savagely if it once gets on fire. Having applied the cement to our rims, we are ready to put on the tires. To do this, first let out all the air in them and then stretch them into place on their respective rims, starting at the valve stem, which is pushed through the hole in the rim provided for it. By working in both directions equally, it will be found that the point opposite the valve will snap into place with but little effort.

The retaining lugs that are molded in the tire, should now be coaxed (we use that word advisedly) into the square holes, in the rim, that are made for their reception. After they are all in place, the screws should be put in, but not at once tightened.

We are now ready to cement the tire on. To do this, the familiar gasolene torch had best be obtained, and after lighting it and turning it down to a small flame, the rim should be heated, evenly and gently, until the cement softens, when the tire should be pumped up moderately hard and the screws tightened in the retaining lugs. Then set the wheels aside for the cement to set. If the tires are put on as above, they will not come off in a hurry.

It is understood that the above method of applying tires can only be followed when the rims are enameled and baked, as is a bicycle frame. If the rims are painted, the tires will have to be cemented on with a liquid rubber cement or with shellac. Neither of these latter equals the former, however. Where painted rims are used the following directions will be found good, as no heat is used, and the stick-to-it value of hard cement will be had. After breaking the cake of cement into pieces about the size of an egg, these pieces are put, one at a time, in a stout piece of cloth, which is then twisted around the cement to form a fairly loose bag, and then pounded into small particles with a hammer. After a sufficient quantity of pulverized cement has been obtained, it should be put into a receptacle and mixed with gasolene by stirring. By first putting in the cement and then gradually adding the gasolene the mixing will be facilitated. After this mixture has stood for about half a day, a small amount of added gasolene should be stirred in. This should be repeated two or three times until a good thick paste is obtained. Each stirring need not take more than five minutes, and if only reasonable care is taken, a paste will be made that is absolutely free from lumps. This paste is best applied with a brush and should be kept in a receptacle as near air tight as possible, such as a Mason fruit jar. In

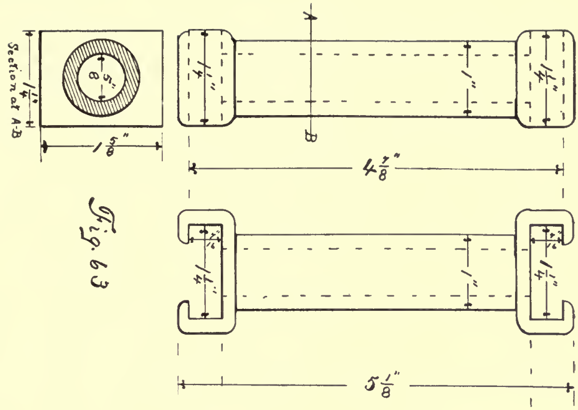


Fig. 63

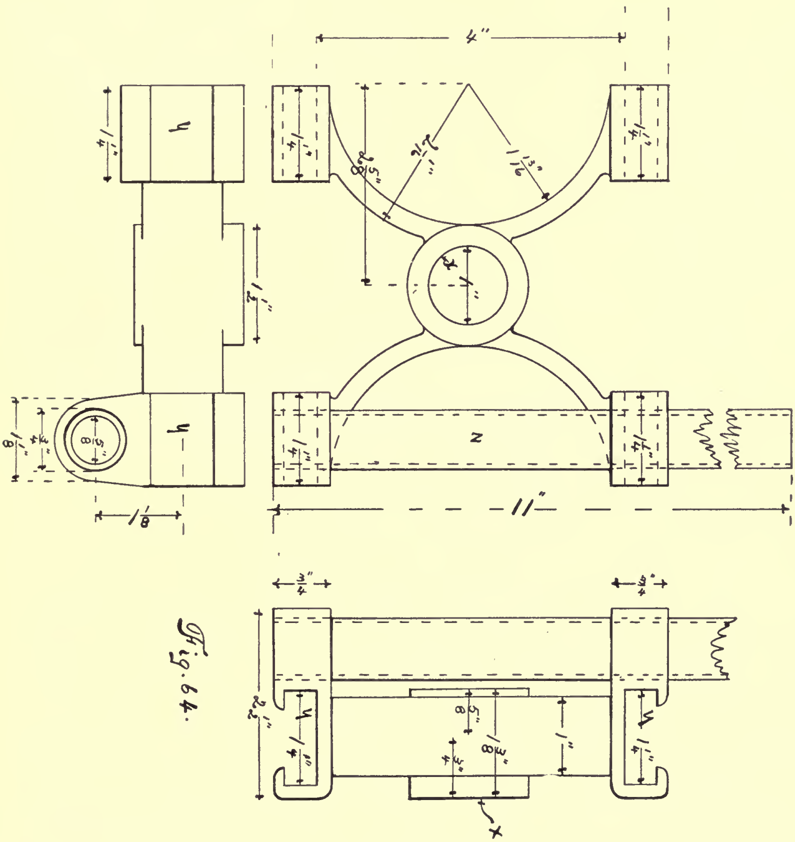


Fig. 64.

using this method it should be understood that it takes about two days for it to thoroughly set, but once set it will cling better and longer than any other method and will not be affected by the coldest weather. It is also the best method to be used should wood rims ever be tried.

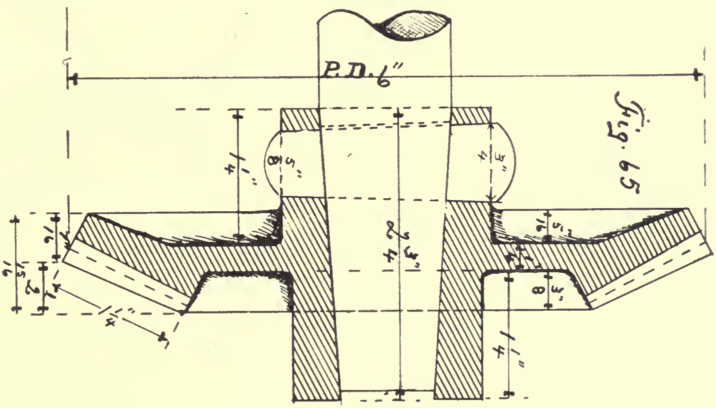
In figure 63, we show the front axle distance pieces, which were shown at a and a′ in the assembled axle. These pieces are steel castings, and after being finished to the dimensions given are brazed into place, as shown in figures 54 and 55.

Figure 64 shows a plan, elevation and end view of the central fixture of the front axle, which serves the triple purpose of a distance piece between the upper and lower members of the axle, a support for the swivel of the main frame, thus allowing for inequalities in the road, and it also forms the support for the tube which carries the steering rod. In machining this fixture, care should be taken to bore the hole square with the slots, y, which take the two axle bars. If this is not correctly attended to the frame will not come together properly. The tube z is a piece of 16 gauge bicycle tubing 3-4-inch open in diameter and 11 inches long, and is brazed into the position shown. Through its center passes the steering rod, to be hereinafter shown.

CHAPTER XIII.

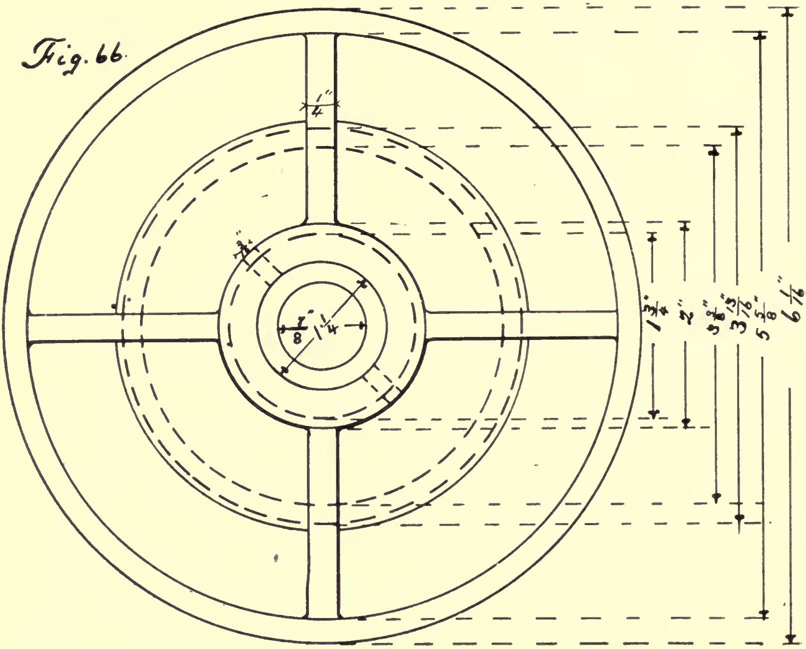
Gears.

Figures 65, 66, 67 and 68 show the details of the differential gear we are using, and one that is heavy enough for a gasolene vehicle. The writer knows of no gear on the market at all fitted for this use. The reason that the transmission gearing and the differential of a gasolene vehicle have to be so much heavier than those in use on steam vehicles is because of the intermittent character of the power of the motor in the former case. It will be readily understood that with a true rotary motor, such as an electric



motor, which furnishes a constant torque, the driving mechanism may be exceedingly light; with a two or three cylinder steam engine equivalent conditions are nearly approached, and corresponding parts may be made but little heavier than with the electric motor, but with a gasolene motor especially of the single cylinder type, heavy transmission gearing must be used. Figure 65 shows a cross section of the bevel gears of the differential and the means of attachment to the axle. The taper fit shown should bear throughout its length

Fig. 66.



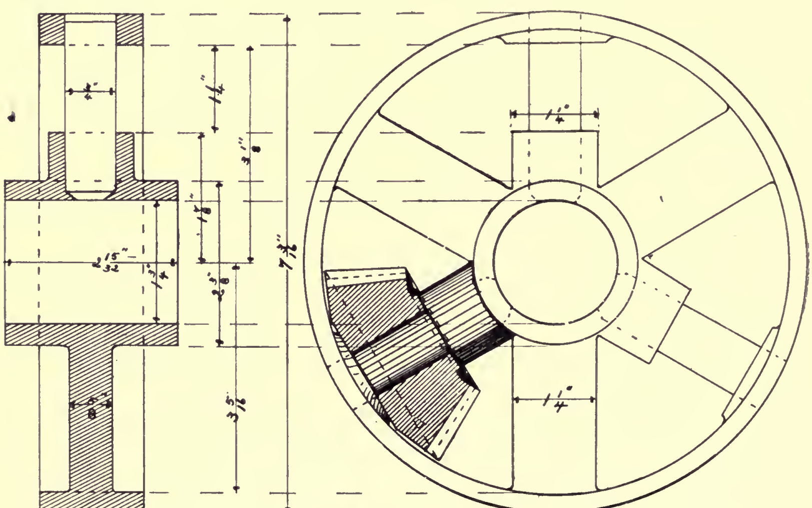


Fig 67

and the key should be so fitted as to draw the gear hard onto the taper. These gears should be made of cast steel or of hard composition. Figure 66 shows a rear view of the same gears. In figure 68 we have an elevation and a cross section of the pinions used in this differential. These should be made of steel to the dimensions given. Figure 67 shows a cross section and an elevation of the spider carrying the three bevel pinions of the differential. The hub of this spider is bored out to fit over the hubs of the bevel gears, figure 65, and the bosses of the spider are bored out to take the 3-4-inch pins on which the pinions run. These pins must be radial, equi-distant and in the same plane, or else the pinions will not all mesh with bevel gears.

In figures 69 and 70, we show a section, an elevation and an end view of the rear hubs for the vehicle we are describ-

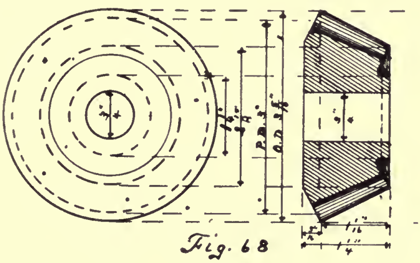


Fig. 68

ing. It will be noticed that the exterior dimensions of the hubs are the same as the dimensions previously given for the front hubs and further that each flange of each hub is drilled for twenty No. 9 spokes. These hubs are best made from good steel castings, like the front hubs.

In figure 71, the outside or wheel ends of the rear or driving axle are shown. This driving axle is made of a piece of 1 1-4-inch mild steel shafting, cut to lengths to be given later. However, the ends are finished according to the dimensions given in figure 71. The critical point in attaching the hubs to the rear axle ends is to have the taper in the hub perfectly fit the taper of the axle, and also to carefully fit the key, both in the axle and in the hub. It is, of course, necessary to have the outer or threaded end of the axle also true with the taper, and to have the outer 3-4-inch hole in the hub true with the taper in the hub, so that when the latter is placed on the axle end the taper of the hub can be forced (by the nut on the axle end) firmly onto the taper of the axle. If the machine work in this construction is properly done, a very strong attachment will result.

In figure 72, we show the cap for the rear hubs, This is the same cap that is used on the front hubs, but as the dimensions were not given in the former case, we have inserted them here. These caps are preferably made of composition, and the round bead of the cap is preferably knurled, so that the cap may be screwed into the hub by hand. A fine thread had best be used for the caps, because they will then

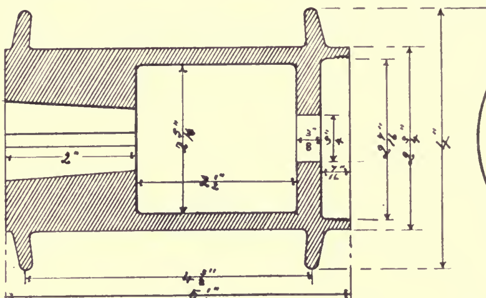


Fig. 69.

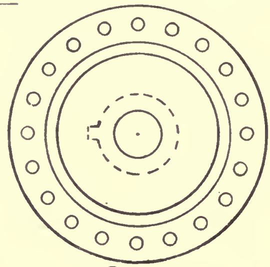


Fig. 70.

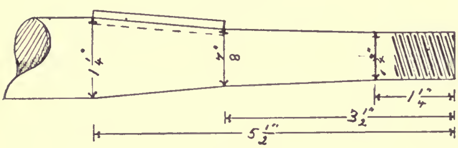


Fig. 71.

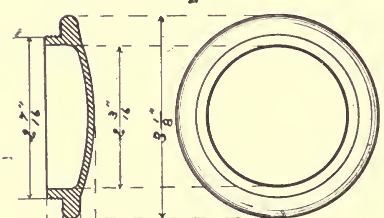


Fig. 72.

be less liable to fall off. A No. 20 thread is sufficiently fine, but the exact pitch is of course immaterial.

It is also well to have the thread on the end of the axle reasonably fine, say, No. 16 pitch. The nut for this thread should be a close fit, and should be of the same general dimensions as the check nuts used on the front swivel axles. This will allow the same wrench to fit in either case.

THE TRANSMISSION GEAR.

A few words about the general arrangement of our transmission gear may not be out of place, before going into the actual details thereof. It must be remembered, in considering the method we shall show of delivering the power of the motor to the driving axle, that simplicity and cheap construction are the governing features in this series of articles. For this reason we shall not, at present, show any means of backing the carriage, as the vehicle we are showing (when completed) should not weigh more than 700 pounds and thus may be easily pushed by hand, if the whole is properly built, and the absence of a backing motion will seldom be felt. We do not say that a means of mechanically backing the vehicle is not a considerable advantage, but we do say that such mechanism adds complication and expense, not to mention the resulting wear and tear, and for this reason we think the amateur well advised if told to get his carriage working to his satisfaction before adding such refinements as reversing gears, methods of starting from the seat, etc.

The transmission gear for the vehicle we are describing consists, first, of two sprocket chains driving from the engine shaft to a countershaft by means of proper sprocket wheels. These latter run free on the countershaft, but may be gripped to the countershaft through the medium of suitable clutches. The countershaft itself drives the differential gear through a spur gear on the latter and a pinion mounted on one of the clutch members which is carried by the countershaft.

THE SPUR GEAR AND THE PINION.

On referring to figure 73, it will be noticed that we have shown our main driving gear to be a ring of H section, the outer surface of which is cut with 76 teeth of 8 pitch, while the inside surface, A, of the gear is turned of such a size as to be a shrinking fit on the periphery of the differential gear spider. If this surface, A, is three or four thousandths of an inch less in diameter than the outside of the differential spider it will be sufficient. This gear may be best shrunk on by placing it on an iron plate, say, 1-4-inch or 3-8-inch thick and then heating the whole over a forge. It may be then easily slipped into place on the differential spider, and when cooled will be found to be very tight thereon. In order to

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prevent its slipping, a 3-16-inch hole may be drilled, half in the spur gear and half in the spider, preferably opposite one of the arms of the differential spider. A round steel pin should then be driven into this hole. The writer uses a strong bronze for the spur gear, but steel may be used instead.

The pinion that meshes with the spur gear is also shown in figure 73. This pinion should be made of steel, cut on its outer surface into 18 teeth of 8 pitch, and its inner surface, B, should be bored for a driving fit on one of the clutch members, to be hereinafter shown. Both this pinion and its co-acting gear should be properly cut or else, considering the

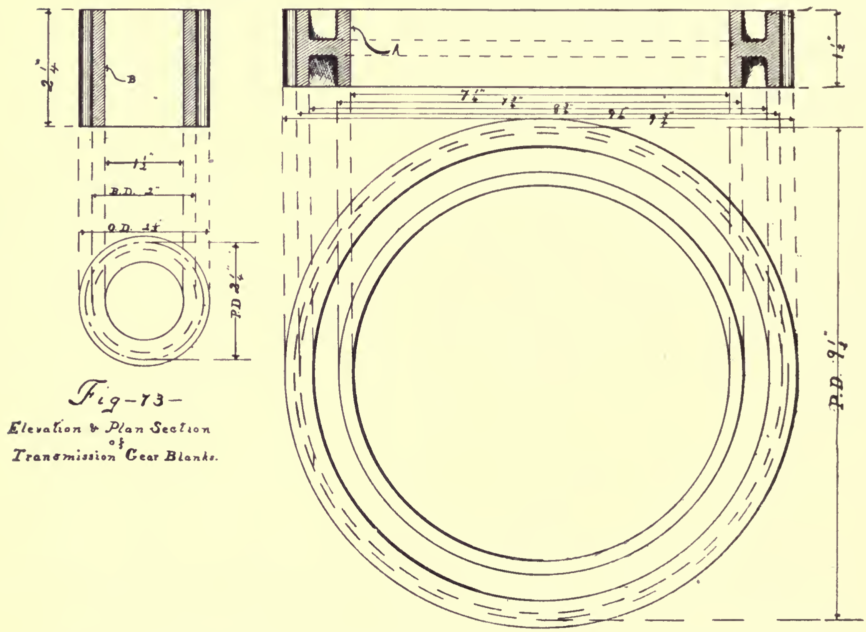


Fig-73-
Elevation & Plan Section of Transmission Gear Blanks.

speed they run, they will be noisy. However, there is no reason why properly cut gears running under anything like proper conditions should make objectionable noise.

THE COUNTERSHAFT.

In figure 74, will be seen a drawing of the countershaft of the carriage we are describing, showing one of the clutch members in position, the high speed driving sprocket and other details.

The following general description will prove useful:

A is the countershaft, which is reduced in diameter for a part of its length, as shown at A 1, and which is threaded at one end, as shown at A 2. The countershaft is further provided at A 5 with a key seat, into which is staked a 3-16 inch key. The reduced part of the shaft, A, carries the clutch member, B, which should be a close fit on the shaft, A 1, and should of course be splined to fit the key, A 5. Next to the clutch member, B, and bearing against its hub is a ten-toothed sprocket wheel, C, which is also a tight fit upon the reduced part of the countershaft, A 1, and is further splined to fit the key, A 5, as was the clutch member, B. A bushing, A 4, is made to slip over the reduced part of the countershaft, A 1, and of such a length as to project slightly over the shoulder at the threaded part, A 2; so that when the nut, A 3, is screwed upon the thread, A 2, the bushing will force the sprocket wheel, C, firmly against the hub of the clutch member, B, and also will force the latter against the shoulder of the countershaft, A.

In figure 74 A, we show the sprocket wheel blank, C, in elevation, as it appears before being cut. In the cutting of sprocket wheels the bottom diameter of the teeth, in this case 2 7-8 inches, is the most important point to have correct. The blank here shown is for a ten-toothed one inch standard pitch sprocket wheel, made for a 1-2 inch chain.

Referring back to the clutch member, B, it will be noticed that its periphery is covered with leather, as shown at B 1. To cover a metal surface of this sort with leather, so that the latter will stay in position against the tortional strains that exist in a clutch of this construction, is quite a trick. But if it is properly done, the leather will stay a long time and will stand considerable hard usage, and this form of clutch is certainly the most simple that can be constructed.

The countershaft, clutch, sprocket wheel and bushing should all be made of steel. The bushing, A 4, may be made of a piece of cold drawn steel tubing, such as is used in bicycle construction, but should preferably be larger than the 1 1-8 inch diameter shown, and then turned down to that size. The bushing should be thus turned down because its outside forms one of the bearings of the countershaft, and it must be true.

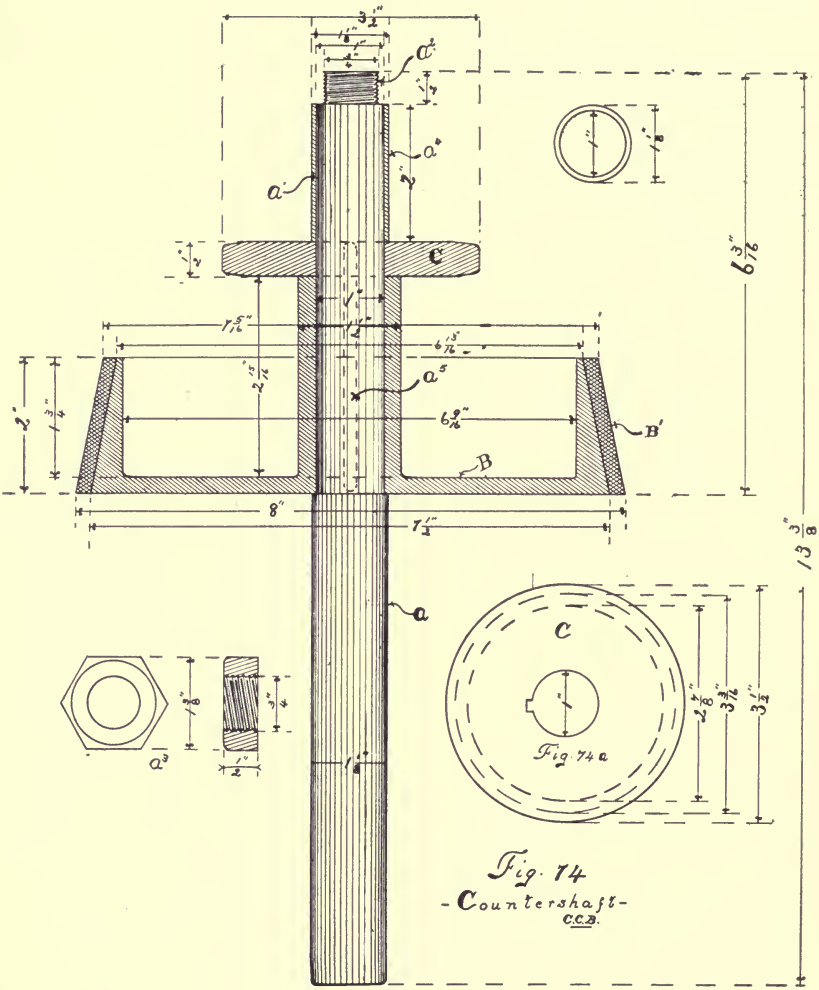


Fig. 74

-Countershaft-

C.C.B.

On referring to figure 75, the reader will see a sectional plan and front elevation of the second member of the clutch of our transmission gearing. This part of the clutch should be preferably made of a steel casting, although a good tough bronze or gun metal may be used.

The following hints on machining this casting may be helpful. The hub, D 2, should be bored out to 1 1-2 inch, as shown, and should be a running fit on the hub of the friction member, B, figure 74. After the hub, D 2, has been bored out and preferably reamed, an arbor should be driven in this hole, D 1. The castings should then be finished on centers. The ends of the hub, D 2, should be faced to the dimensions given and also the projection, E, which is to form the large sprocket wheel of the transmission gear. The interior slanting face of the clutch should also be faced off, but should be left rough; that is, as the tool leaves it after a coarse cut. The slanting face is best made on a lathe equipped with a compound slide rest, which should also be used in turning off the leather facing, D 4.

The blank, E, for the sprocket wheel should be turned off on the outside to a diameter of 9 56-100 inches, and should then be cut, while still on the arbor, with 29 teeth, standard, one inch pitch, the bottom diameter of the completed sprocket should be 8 9-10 inches. It is important to have the bottom sprocket diameter correct.

The best way to cover the face of the clutch member, B, figure 74, and the face, D 3, of the clutch member, D, figure 75, is as follows: First cut out a piece of good sole leather or belt leather to the required shape to fit the face to be covered, but have the leather of such a length that the ends will overlap about two inches. These overlapping ends should then be carefully scived down to a very thin edge. The leather should then be replaced on the part to be covered, and the position of the ends carefully marked, so that when the leather is removed the operator can tell where to glue the joint. When the leather is placed on the outside of the clutch member, as in B 1, figure 74, it is well to overlap the ends about 1-8 inch more than the mark shows so that when the joint is glued up the ring will be slightly smaller in diameter than the surface it is to fit. When it is finally

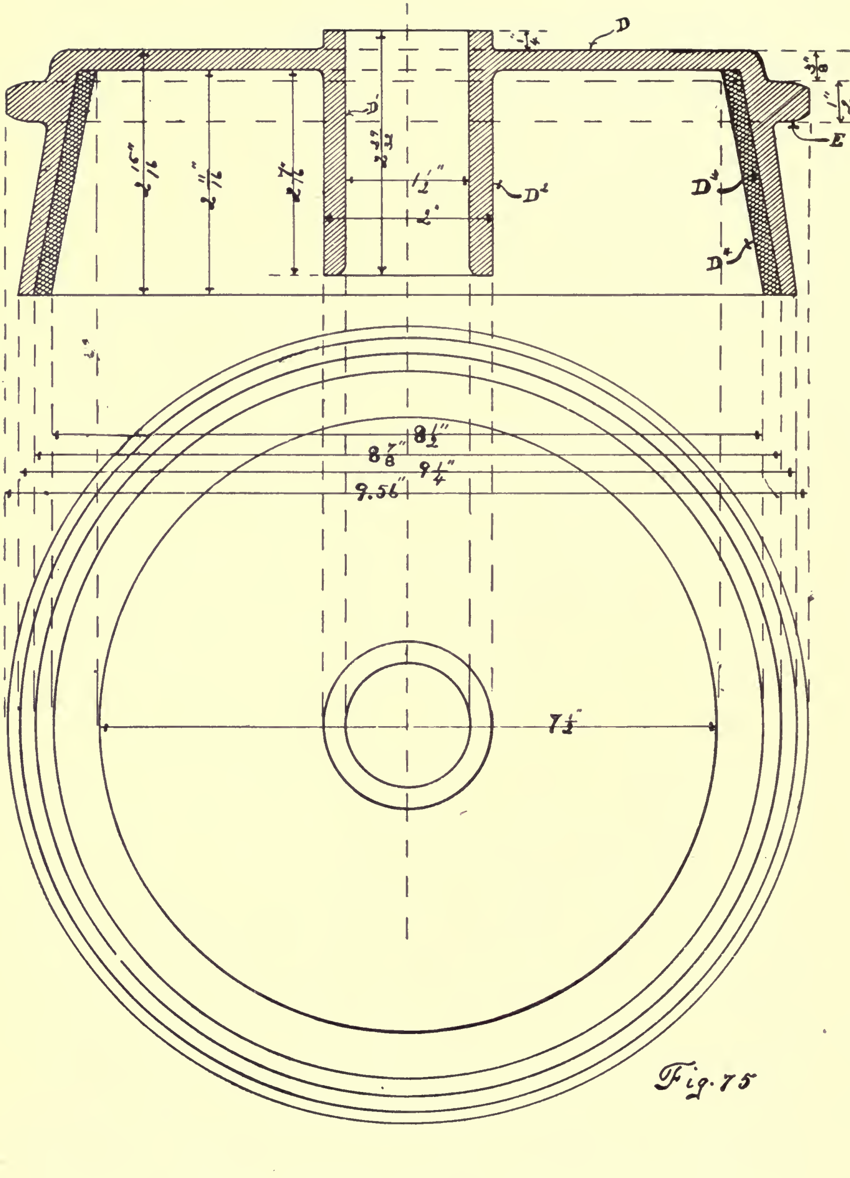


Fig. 75

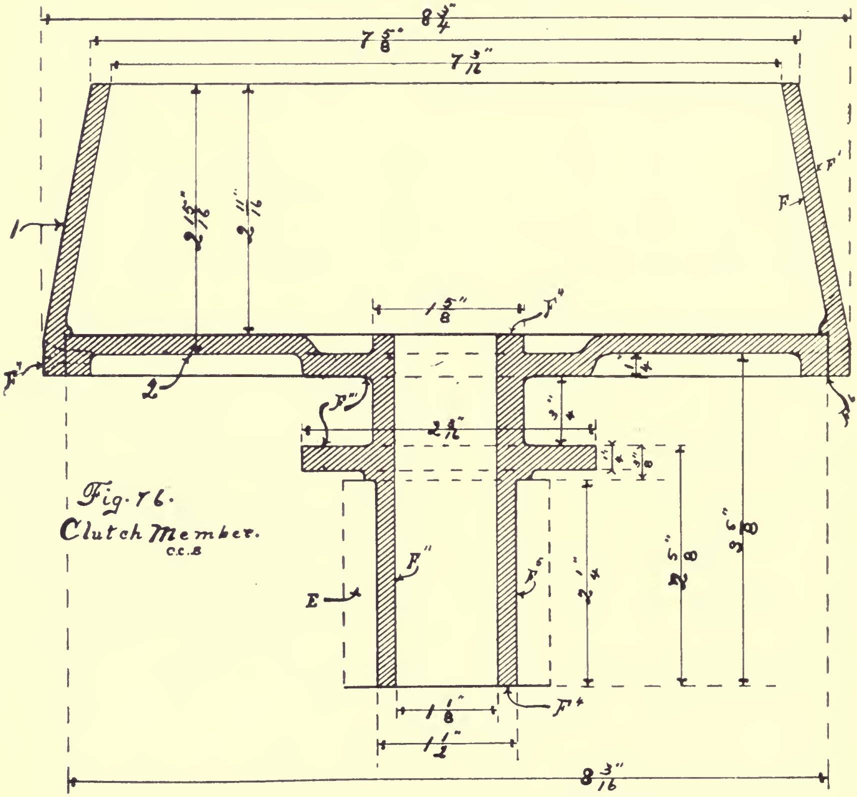
placed in position it may be squeezed down hard upon the metal face of the clutch member, thus enabling the glue to better hold it in position, on account of its perfect contact with the surface to which it is glued. It will be obvious that where the leather is to be fitted on the inside of a slanting face, as at D 3, figure 75, the overlapping ends of the leather should be separated about an eighth of an inch, thus making the leather ring slightly larger in diameter than the surface to which it is fitted.

The best way to glue up these leather rings is to size the scived ends with good hot fish glue and to let them dry. They should then be coated again, placed in position, and held fast between the jaws of a hand clamp or vise, until the glue is thoroughly set. Each ring should then be carefully sand-papered on the surface next to the metal face of the clutch. After this is done the surface should be sized with hot and thin fish glue. The metal surface should now be carefully cleaned with soda or gasolene, preferably the former. Both the face of the leather and the face of the clutch should be now quickly and evenly covered with a coat of thin glue and the leather can then be quickly placed in position and clamped there with a pair of hand clamps. The whole should be left in this condition until the glue has thoroughly set.

The hand clamps may be then removed and three rows of holes drilled through the leather and through the clutch face, one row on either edge and another row in the middle. These holes should be about one inch apart around the circumference of the leather, and it should be of such a size that ordinary hard wood shoe pegs will be a driving fit into them. One shoe peg should then be driven in each hole from the leather side, until the head of the peg comes flush with the leather. After this is done, the other ends of the pegs should be broken off about 1-16 inch beyond the metal face of the clutch member, thus leaving the ends of the pegs projecting 1-16 inch from the surface. This surface and the ends of the pegs should then be given two or three coats of shellac. Each coat being allowed to get thoroughly hard before the next one is applied. This method of treatment will cause the pegs to swell out slightly and thus, on acount of their larger diameter, and by the ring of shellac that will naturally stick to them, they will be held securely from pulling back.

The clutch members may be now put on centers and the leather faces carefully and smoothly turned off. To do this properly a high speed should be used and a sharp tool with plenty of draft. If the above directions are carefully followed, a very good job will result.

We show, in figure 76, the third member of our clutch device. This is made from a steel casting to the dimensions



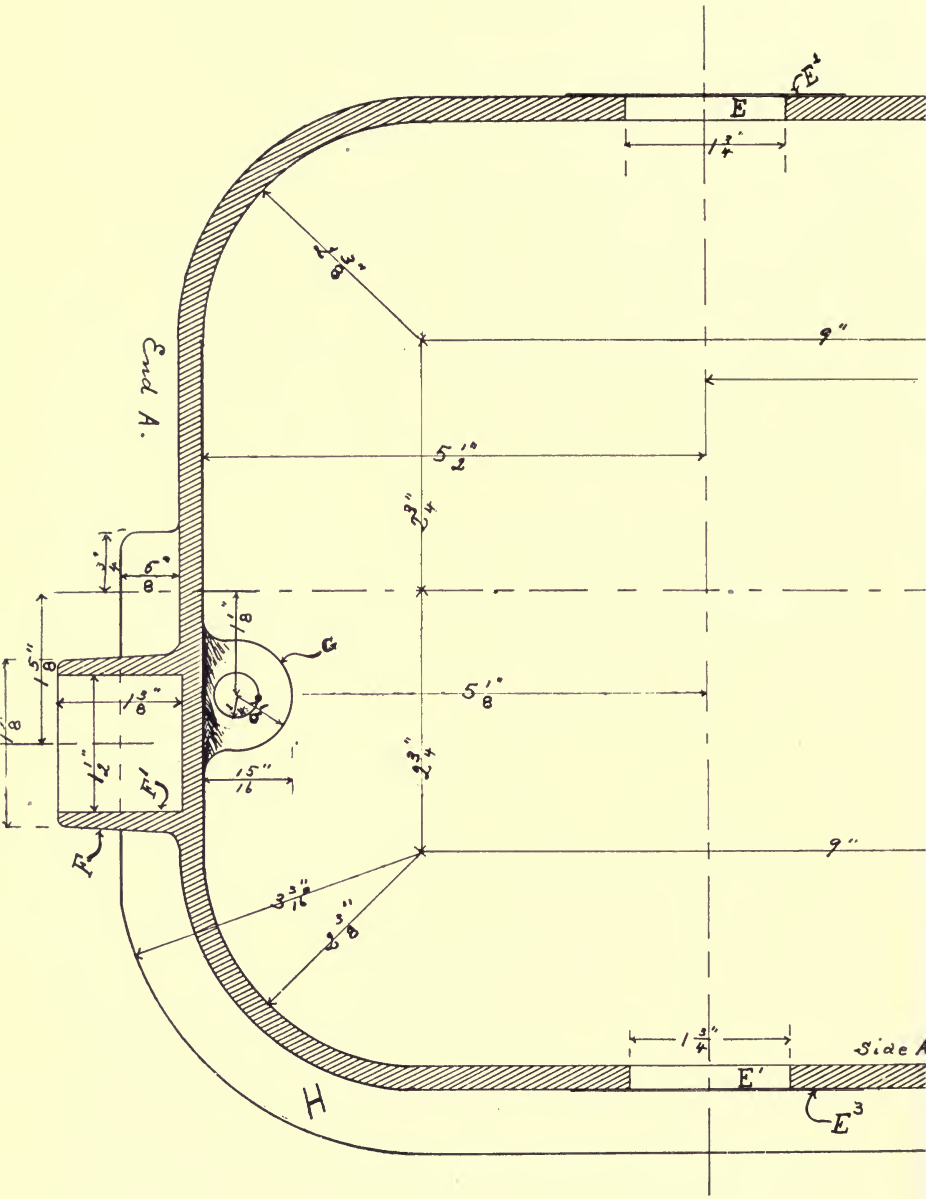
given in the sectional plan. The following points on machining should be observed.

The hole, F 2, should be bored and reamed a running fit on the shaft, A, figure 74. The casting should then be driven on an arbor and the ends of the hub, F 4, should be squared. The edge, F 6, should then be turned off to 8 3-16 inches diameter as shown. That part of the clutch shown at 1 should then be put in a chuck and its inner face, F 6, turned out a shrinking fit on the other part of the clutch. Part 1 should now be removed from the chuck, heated, and part 2 should then be driven into position as shown.

Part 1 should now be drilled and countersunk to receive eight 1-4 inch flat headed machine screws, which should be tapped into part 2, as shown, dotted, at F 7. The whole should then be placed in the lathe on the arbor, as before, and the inner face, F, should be carefully turned to fit the leather face of the clutch member shown in figure 74, while the outside face, F′, should also be carefully turned to fit the leather face of the clutch member shown in figure 75. The groove, F 3, should now be machined to the dimensions given. This groove is intended to receive the shipper to be hereinafter described.

In figure 77, we show the yoke or frame of the transmission gear. This frame is an integral part of the vehicle frame. It is made either of cast steel or of malleable iron. If of the former metal, it may be made to the dimensions given, in which case the walls or ribs will be 3-16 inches in thickness, but should malleable iron be used the web and bosses should be made 1-4 inch in thickness.

The following description of the functions of this frame will aid the reader to better understand the drawing. The center line, D, figure 77, is also the center line of the rear axle, which passes through the bosses D-1 and D-2. The outer surfaces of these bosses, at D-3 and D-4, should be machined to closely fit pieces of 2 inch 13 gauge cold drawn steel tubing, which tubes are to be brazed on the outside of these bosses. These tubes form the outer casing of the rear axle. They will be shown in the frame drawing hereafter to be described. It is necessary that in machining the outside of the bosses, D-1 and D-2, care should be taken that they exactly line up, otherwise the rear axle will not run freely. At the same time that these bosses are being machined, the pockets, D-5 and D-6, should also be bored out for the axle bearing cases, to be hereinafter shown. In machining these pockets, great care should be taken not only to have them in line with respect to each other, but also that


E
E²
E'
E³
End A.
G
H
F
F'
9"
5 1/2"
5 1/8"
2 3/4"
2 3/8"
3 3/16"
1 3/4"
15/16"

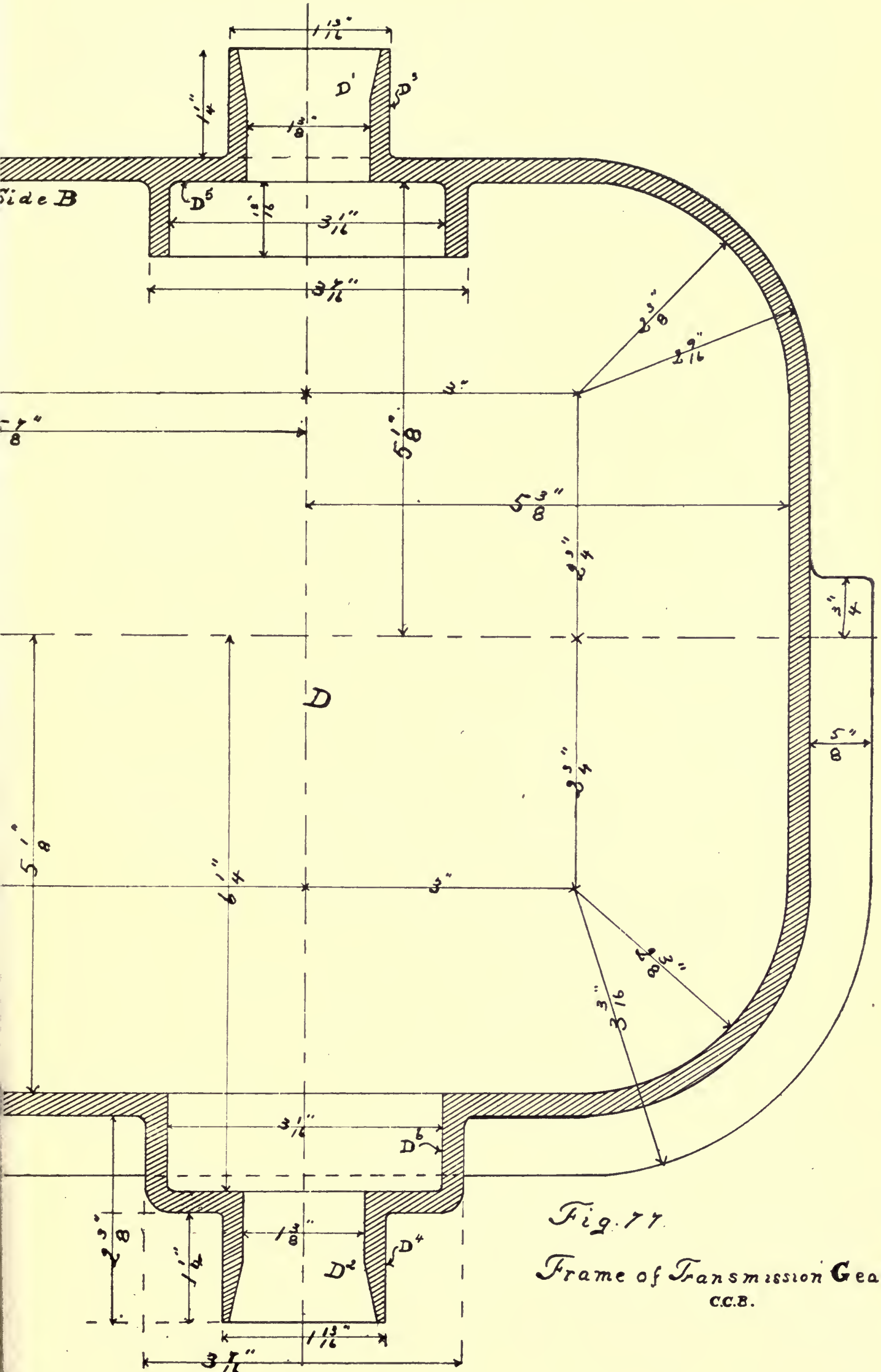


Fig. 77.

Frame of Transmission Gear

C.C.B.

they may be concentric with the surfaces, D-3 and D-4, of the bosses D-1 and D-2.

The next part of this casting requiring our attention will be the surfaces that will carry the countershaft bearings. Referring to figure 77, E and E-1, are the holes through which the countershaft passes, and they should be bored out to the dimensions given. And at the same time the surfaces, E-2 and E-3, should be machined. It is necessary that these surfaces be true with each other, and also that the holes, E and E-1, shall be in the same plane with and parallel to the surfaces of the rear axle bearings, D-5 and D-6. Otherwise the gears will not run smoothly.

The next part of the casting to demand our attention is the boss, F, which is to be machined on its inner surface, F-1, to closely fit a piece of 1 1-2 inch 10 gauge cold drawn steel tubing. This tube forms one of the side bars of the vehicle frame, and will be brazed into the boss, F. Immediately behind the boss, F, will be seen another boss, G, which forms one of two supports for the clutch shifting-lever; the other similar boss is shown in dotted lines, at G-1, figure 77-A. It will be observed that the outer surfaces of the bosses, G and G-1, are flush with the top and bottom face of the frame casting, as shown in figure 77-A.

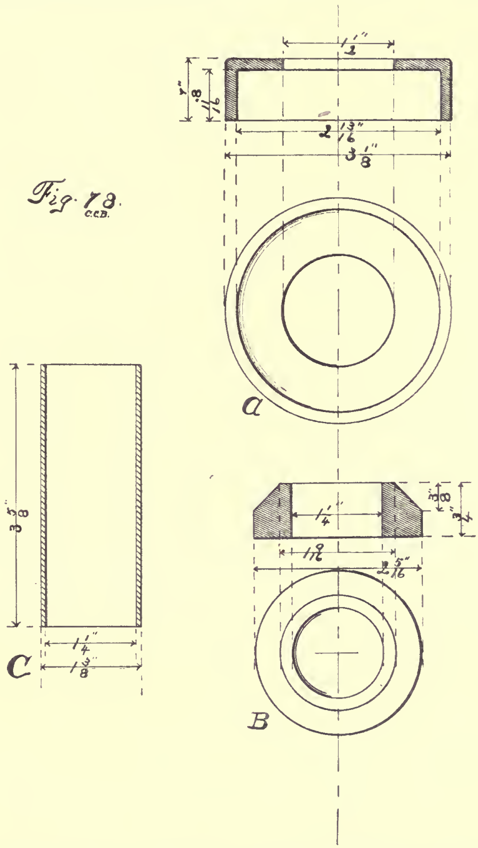
In considering figures 77 and 77-A it will be noted that like figures and like letters of reference refer to like parts.

The ribs, H, figures 77 and 77-A, are for the purpose of strengthening the casting and at the same time to afford a means to attach the dust covers for the protection of the gearing, and while it is not essential it will be found better to plane the surfaces of these ribs.

In figure 78, we show, at A, the ball bearing cups that are to be used for the rear axle bearings. Four of these cups will be required. Two for the outer ends of the axle and two for the inner or differential, ends. The cups on the outer ends of the axle will be shown in position when the rear axle is illustrated. The other cups will be shown in the assembled drawing of the transmission gear. This drawing will further show all of the details that we illustrated in their respective positions. In figure 79, B illustrates the cones to be used with the cases just mentioned. There will, of course, be required four of these cones.

In figure 78, C shows a steel bushing easily made of a piece of 1 3-8-inch cold drawn seamless steel tubing. This bushing should fit loosely on the rear axle as it acts only as a distance piece between one of the cones and the hub of one of the bevel gears of the differential. The assembled mechanism will be clearly shown hereinafter. It is of course

Fig. 78.



understood that the cups and cones should be turned and of a good quality of tool steel and carefully hardened and ground in order to make a good job. Half-inch selected balls should be used for these bearings.

On referring to figure 79, the bearings for the counter-shaft of the transmission gear are shown. The bearings, A, should be bored and reamed a running fit for the bushing, A 4, figure 74. This bearing piece should then be put on an arbor and the ends of the hubs and the flange, a, squared. The outside of the hub, a′, should be turned to the size given. The flange should then be drilled for four 21-64-inch holes, as shown in the elevation. At B we show the bearing for the other end, A, of the countershaft of the transmission gear, figure 74. This bearing should be carefully bored and at the same time the end of the hub, b, and the

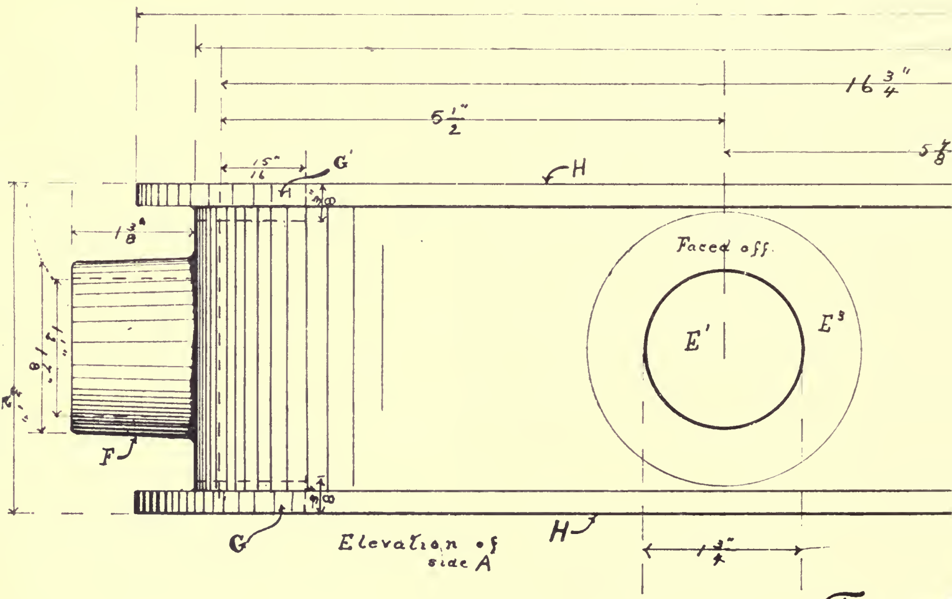
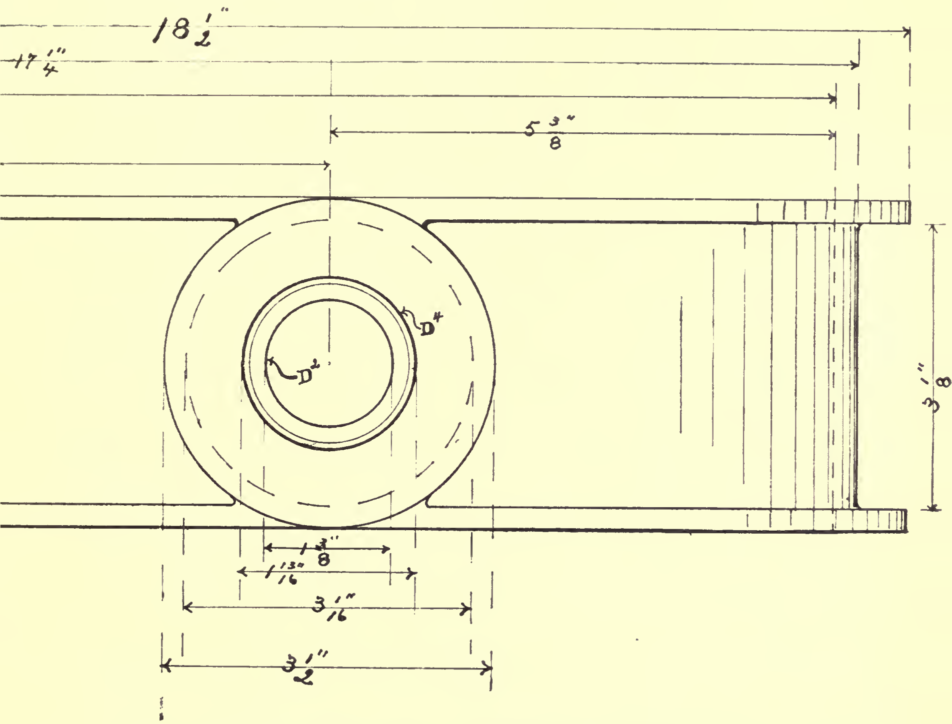


Fig. 77 A

flange, b′, should be squared, and the outside of the hub, b″, should be turned to 1 3-4-inch diameter. The flange should then be drilled with four 21-64-inch holes, as we have already done with the flange, A, of the bearing. These holes are for the purpose of attaching the bearings to the frame of the transmission gear. These two bearings should be made of phosphor bronze or some other good anti-friction composition.

We show, in figure 80, a plan view of our transmission gear as it appears when completely assembled.

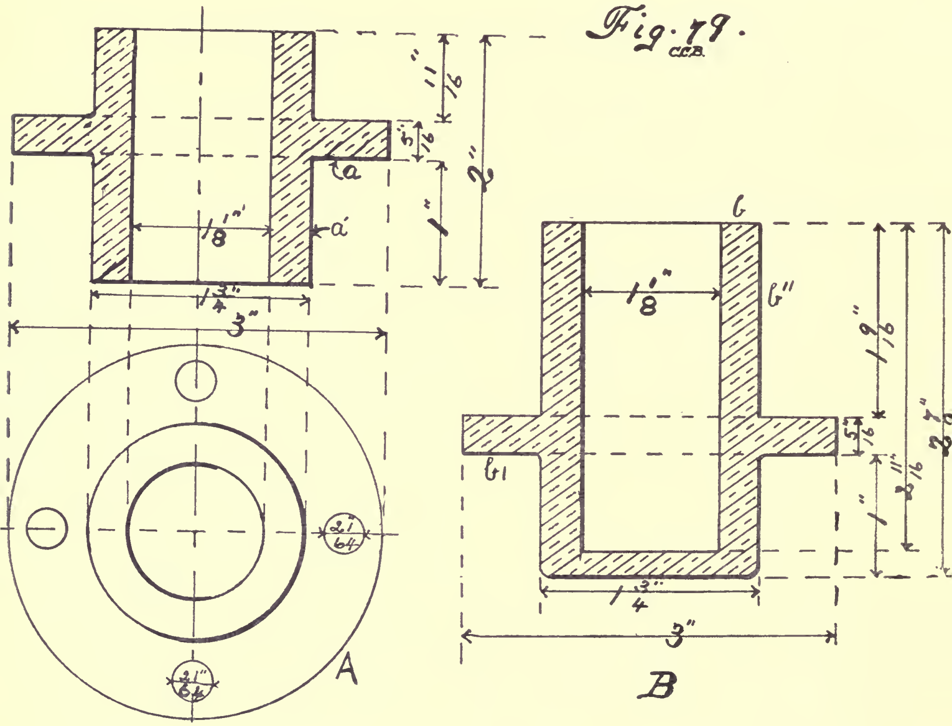
In describing the various parts and functions of the transmission gearing we shall refer back to figure 77, in which will be seen in cross plan section the main transmission gearing frame, and in the text therewith we point out that this transmission frame is built into and forms an integral part of the vehicle frame. Figure 80 more clearly indicates this construction, and by referring to that drawing a short section of the side tube of the vehicle frame will be seen brazed to the left-hand, or front, end of the transmission



gearing frame. Figure 77. On the right-hand side of the drawing, at the top and at the bottom, are shown sections of the vehicle axle tubes. In the description of figure 77, we mentioned that these axle tubes were to be brazed to bosses, d-3 and d-4, of the transmission gear frame. It is evident that these axle tubes, in conjunction with the transmission gear frame, figure 77, form the supporting axle of the vehicle, while the solid shaft, marked "axle," which is concentric with the axle tubes, takes only the torsional strain due to the driving of the vehicle.

In order to emphasize this distinction, we shall in future references designate the solid axle as the "driving axle" and the supporting axle we shall call the "tubular axle."

The method of assembling the driving axle and differential gear parts we will describe later. At present, we will state only that the inner (or differential) ends of the driving axle run on ball bearings contained within the bosses, d-5



and d-6, figure 77. The cups and cones of these ball bearings are shown in figure 78 A and B.

The tubular distance piece, figure 78 C, which is placed over the driving axle (between the hub of the differential bevel gear, figure 65, and the ball bearing cone, figure 78 B) so as to hold this ball bearing cone in proper relation with the differential gear.

Let us suppose for the moment that our driving axle and differential gear are assembled, as shown in figure 80. We may now give our attention to the countershaft, A, figure 74. This countershaft is for the purpose of carrying the clutches, the sprocket wheels and the driving pinion. The following instructions should be observed in properly assembling the countershaft. On the reduced end of the countershaft, A, figure 74, the clutch member, B, should be forced into position. This detail is clearly shown.

Now take the clutch member, 1, figure 76, and place it in the position indicated in figure 80. Then on the large end of the countershaft, A, slide the supporting disc, 2, figure 76, and force it into the recess of the clutch member, 1, figure 76. Now put in screws shown at F-7. Over the hub of B, figure 74 (shown again in figure 80), let us now slide on clutch member, figure 75, and we will then be ready to slide into position the sprocket wheel, C, and the tubular collar, A-4, figure 74. It is of course understood that the clutch member, figure 75, should have a slight end play between the disc of the clutch member, B, and the sprocket wheel, C, figure 80.

Having now all the parts mounted on the countershaft, A, we are ready to place the countershaft within the transmission gear frame, figure 77. So let us push the large end of the countershaft through the hole intended for the bearing, figure 79-B, until the threaded end of the countershaft, A-2, will pass through the hole to be occupied by the bearing, figure 79-A. Bearings, figure 79-A and figure 79-B, may be now bolted into place. The washer, A-6, may be now put into place and the nut, A-3, may then be tightened, so as to bind the clutch member, B, figure 74, and the sprocket wheel, C, figure 74, against the shoulder on the clutch shaft, A, through the medium of the tubular collar, A-4, figure 74). With the exception of the shipper for the clutches, which will be hereinafter shown and described, we have now completed the transmission gearing.

On referring to figure 80, it will be understood that the clutch member, 1, figure 76, should contact with the leather face of B, figure 74, before the pinion, figure 73, touches the end of the bearing, figure 79-B, as is shown in the drawing.

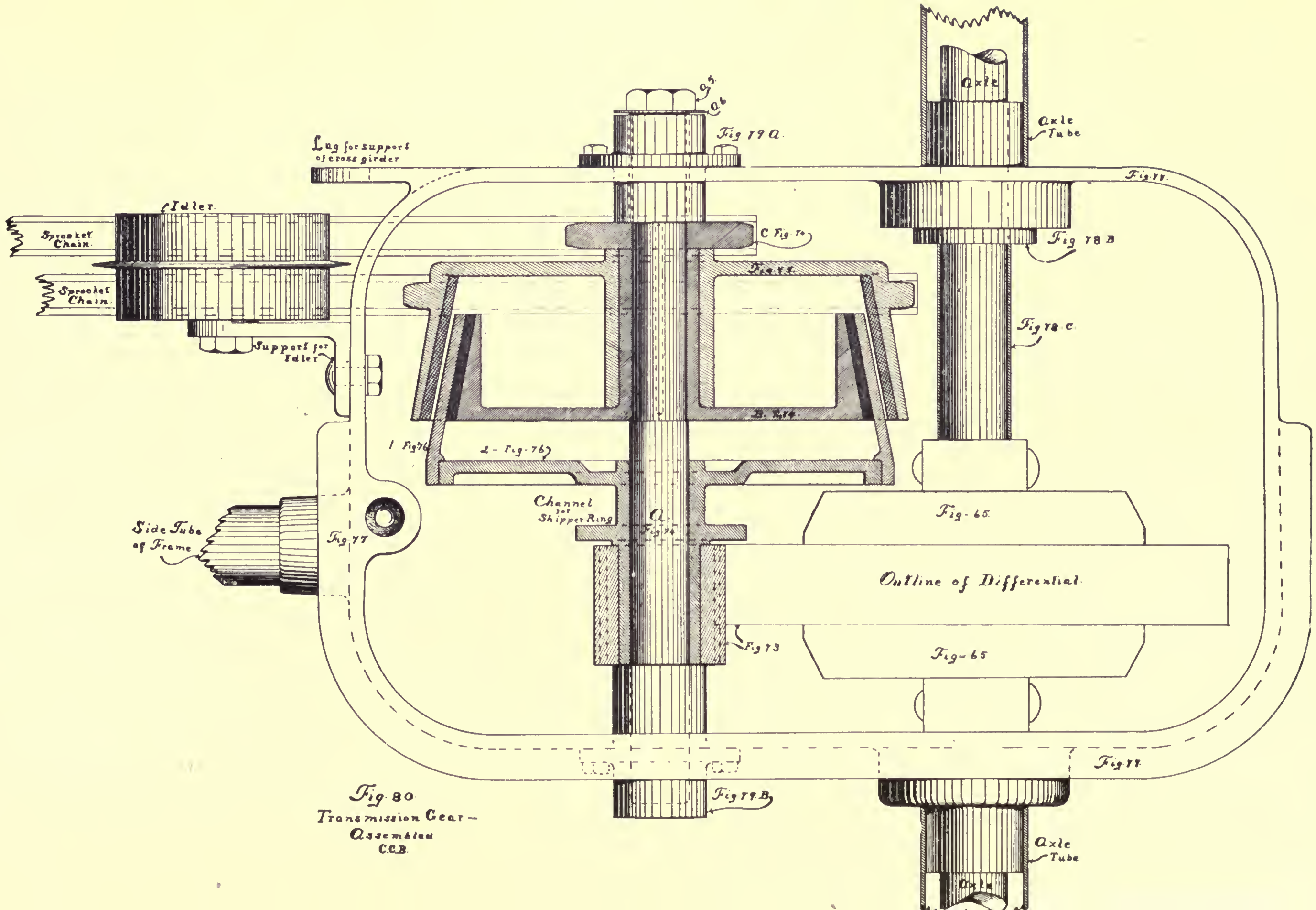


Fig. 80
Transmission Gear — Assembled
C.C.B.

We show it in that position for the purpose of illustrating the entire travel of the clutch member, 1, figure 76, and also of showing how the width of the pinion, figure 73, (being wider than the gear surrounding the differential) allows for the full contact of the gear teeth, whether the shifting clutch member be placed on the fast or on the slow speed.

The idler shown to the left in figure 80, is for the purpose of regulating the tension of the two sprocket chains, and the central rib on the periphery of the idler pulley is for the purpose of preventing the chains from swaying.

The accompanying illustration, figure 81, shows the detailed drawings of those parts of our transmission gear that have not been described before.

The idler is a cast iron pulley best shown in the sectional plan. It is provided with a central flange for the purpose of keeping separated the fast and slow speed sprocket chains. Its hub has an enlarged angular space midway in its length, which acts as an oil reservoir; communication with wheels is had by removing the machine screw nominally occupying the hole marked oil. In order to lighten this idler as much as possible, we prefer to bore several holes through the web as shown in the elevation. It will be understood that two sprocket wheels may be used running on a common hub in the place of the pulley we show. This latter method makes a better job, but we have shown the cheapest construction. The periphery of this idler may be leather-covered to stop the noise of the slapping of the chain upon its surface while running.

In the upper left-hand corner of figure 81 will be seen the stud on which the idler rotates, and the support for same. This stud should be turned of tool steel, whilst the support may be made of a steel casting. The slot in the foot of the support, through which the bolt passes that holds it in position, is for the purpose of obtaining a vertical adjustment so as to tighten the chains when they stretch.

Our clutch shipper consists of an arm, figure 81, (journaled between the lugs G, figures 77 and 81) a thumb collar or shipper ring, B, carried between the jaws of the shipper arm, A, and a universal joint, C, by which the shipper arm is connected, through the medium of a link, with the hand

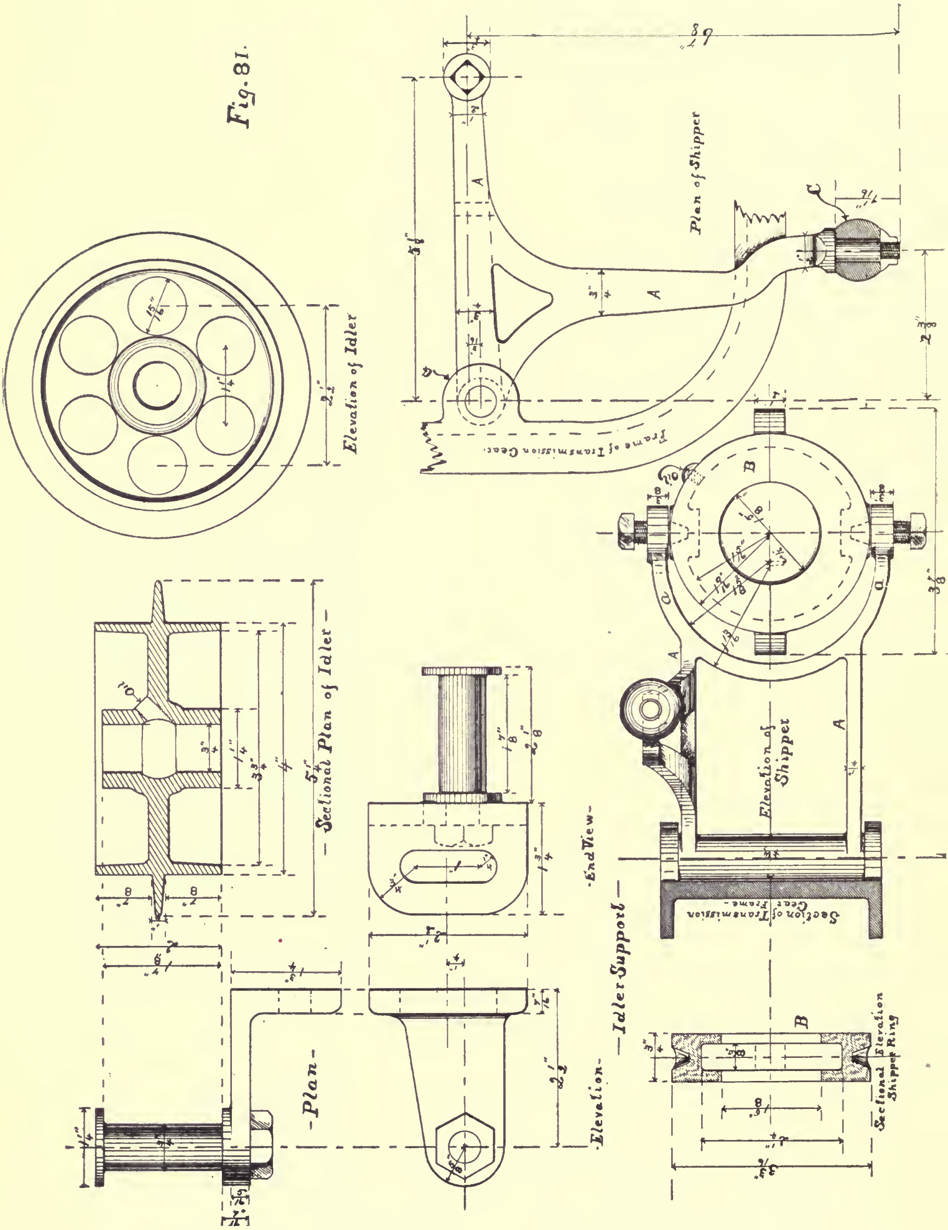

Elevation of Idler
Plan of Shipper
Frame of Transmission Gear.
Sectional Plan of Idler
End View
Elevation of Shipper
Section of Transmission Gear Frame
Idler Support
Plan
Elevation
Sectional Elevation Shipper Ring
Oil
A
B
C
a

Fig. 81.

lever to be hereinafter shown. This shipper is made of a steel casting, and the arm carrying the universal joint, C, is bent upwards so as to pass over the flange of the transmission gear frame; its other arms, a, partly encircle the bronze shipper ring, B, which latter is held pivotly in place by means of two conical pointed cap screws passing through the bosses on the extremities of the arm, a, and entering the conical holes in the shipper ring. As the shipper ring is made in halves, so that it can be placed in the channel in which it runs, figure 80, it will be necessary to dowel the two halves together before turning off the faces. After this has been done, the conical holes for the reception of the cap screws should be drilled and counterbored, care being taken to have them diametrically opposite and equidistant from the sides of the ring. In order that this ring should be well oiled, we have channeled it out on the inside so that it may be filled with vaseline or some other grease. This may be replenished, through the oil hole as necessary. The universal joint upon the end of the arm, A, consists of a steel ball, C, which is held in position upon the projection of the arm, A, by a nut, so that while it cannot come off, it is free to turn. This is clearly shown in the illustration.

CHAPTER XIV

Complete Frame of Vehicle

We have dealt with all chief features entering into the construction of our carriage, with the single exception of the complete frame. In order to aid the reader to properly understand the functions this frame has to perform we have decided to give an elevation and plan of the completed vehicle before showing the frame itself. If the reader will refer to figures 82 and 84, he will, with the aid of the following description, get a very clear idea of the finished machine. In this description like figures refer to like parts in figures 82, 83 and 84.

On turning to figure 82, it will be seen that the left-hand front and rear wheels have been removed and a portion of the carriage body broken away in order to give a more comprehensive idea of the working parts of the vehicle and their relation to each other, while in figure 84, it shows the truck with body removed for the same reason. We have, however, in the latter instance indicated the relative position and shape of the body by a double line.

In describing these two drawings let us begin with the frame. This is best shown in the plan figure, 84, in which, A 6, are the side tubes of the frame, and A 2 the rear driving axle, which is within and concentric with A 22, the rear tubular axle, A, is the transmission gear frame which forms part of the structure. A 25, are the frame guides, which serve the purpose of supporting the motor, A 7, and the water tank, A″, figures 82 and 84. A 24, is the third girder, which carries the ends of the side tube, A 6, and also supports the forepart of the frame by means of the swivel pin, A 26, which is carried in its turn by the front axle, A 23, which has been previously shown.

This frame as above described is shown in detail in figure 83, where it will be seen that the girders, A 25, are

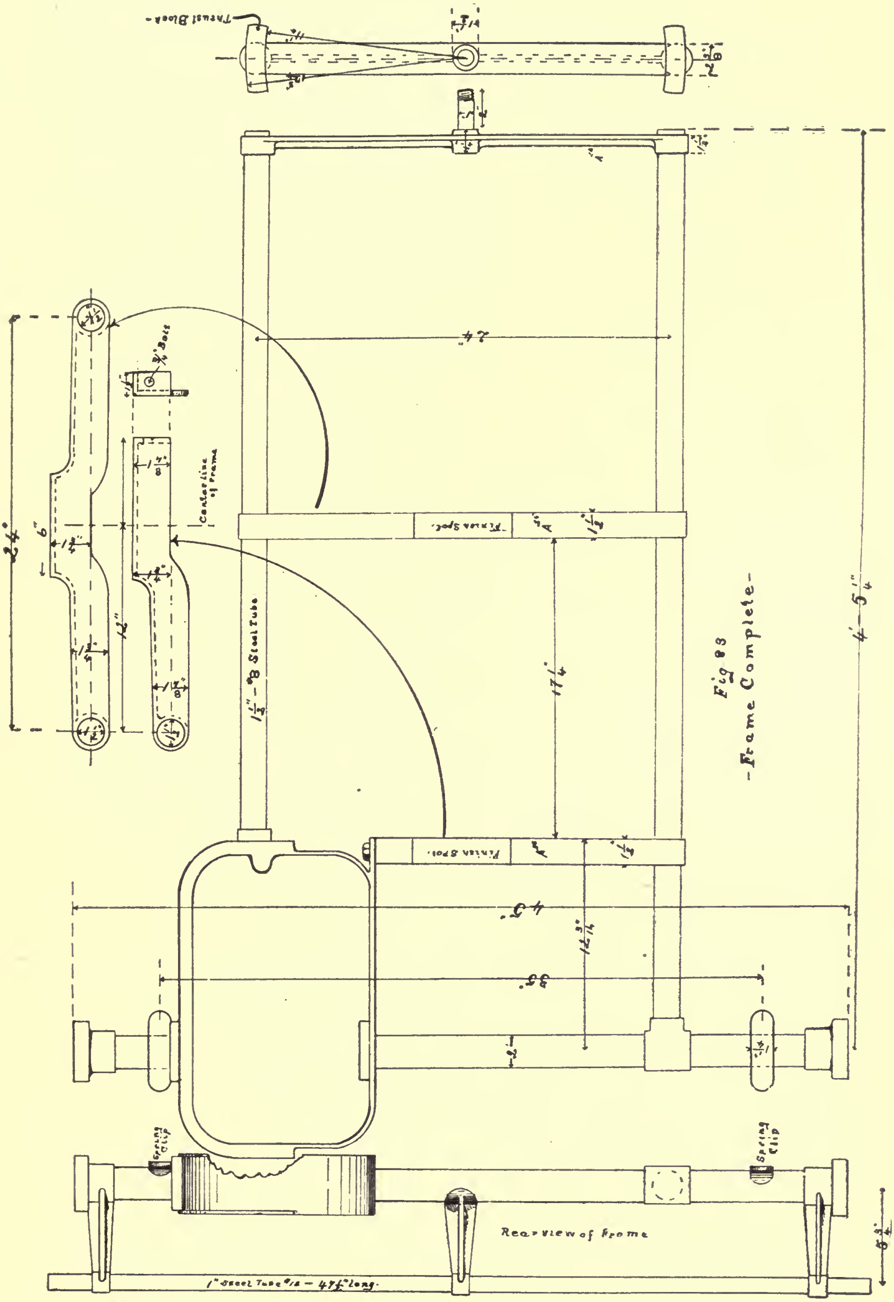


Fig 83
- Frame Complete -

raised in the center so as to elevate the motor casing, A7, figure 82. These girders, together with the one shown at A 24, are cast of steel and should be of 1-4-inch section. On referring to the rear view of the frame, figure 83, it will be seen how the tubular axle is trussed so as to strengthen it. The details of the axle ends, which also form the truss members, will be given later.

To return to our description of figure 84. A 7, is the motor case; A 8, the cylinder; A 9, the induction, or vapor, pipe leading from the atomizer, A 15, which is contained within the gasolene supply tank, A 14, (to be hereinafter described) to the inlet valve of the motor. The gasolene tank, A 14, is carried within the body of the vehicle. The supply pipe, A 9, must therefore be flexible so as to allow for variations in the relative positions of the tank and the inlet valve of the motor, caused by the yielding of the carriage springs. We will refer to this again.

As before stated, A 11, is the tank in which the supply of cooling water is carried. This tank is connected, preferably by heavy rubber tubing, with the motor water jacket, A 8, by two pipes, one, A 10, leading from the top of the water jacket to the top of the water tank, as shown, whilst the other pipe, A 20, leads from the bottom forepart of the water tank to the bottom of the cylinder water jacket, as indicated by dotted lines. We take this latter, or supply pipe, from the forepart of the tank because the water at this point is cooler than at any other part, on account of the better draughts of air received as the carriage moves forward.

As previously stated, A, is the transmission gear frame which carries the clutches, high and low speed sprocket wheels, etc. The power is transmitted from the motor shaft to the two speed gear by means of the sprocket chains, A 3, while these latter are adjusted to the proper tension by means of the idler pulley, A 5.

The exhaust pipe, A 12, conveys the gases, after ignition, to the muffler, A 13, where the force of its movement is largely destroyed and the noise thus considerably reduced. The construction of mufflers varies much, the one we shall show being patterned after the De Dion type, which acts fairly well for an easily constructed affair.

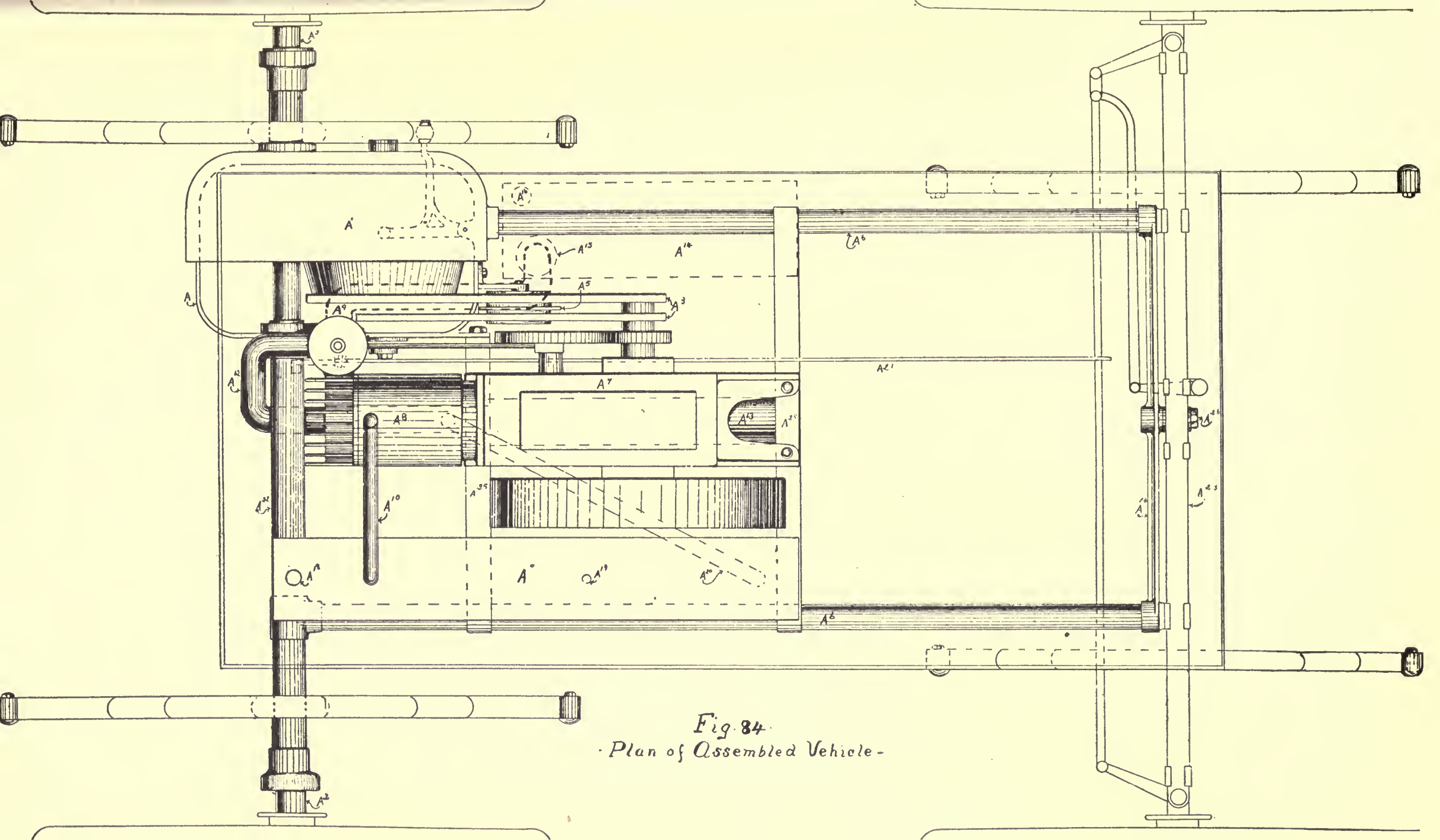


Fig. 84.
· Plan of Assembled Vehicle ·

If the reader will refer to the first few chapters, he will find the various methods of forming a suitable gaseous mixture, from the intermingling of gasolene with air, explained in considerable detail, and the data therein given will aid the amateur materially in understanding the exact functions of the atomizer to be described in this chapter. Our object in referring to the previous chapters is that they deal with the action or principle of the various devices for obtaining a combustible mixture, while our present chapter merely deals with the mechanical construction of an extremely simple and fairly satisfactory form of atomizer.

We wish to say, however, that we do not offer this atomizer as the best form that can be made, for undoubtedly the float feed form is superior in that the level of the gasolene is always constant, and, further, the noise of the rapidly moving baffle plate is dispensed with. A properly designed float feed atomizer, or carburetor, is an exceedingly difficult piece of mechanism to construct, unless one is especially fitted for their manufacture, therefore, it is out of bounds for that class of readers for whom this book is written.

On referring to figure 90, there will be found a sectional illustration of a simple form of atomizer or mixing valve. We have designed the valve as shown, so that it may be soldered into the gasolene tank and thus do away with all piping carrying liquid gasolene, and at the same time we are enabled to do away with a stuffing box or gland for the central regulating screw, as its bearing extends above the level of the gasolene.

This atomizer, as shown, consists of four distinct parts, viz.: The main casting, A, of brass; the dome, B, also of brass; the baffle plate, C, preferably of steel, and the valve, E, of steel.

The main casting, A, consists of a long stem, a, which is centrally supported in the ring, a 2, by two arms, a 1. The ring, a 2, is turned off, to give easy fit in a piece of two-inch brass tubing, D, of 20 gauge and five inches long. The lower and enlarged portion of the ring, a 2, is threaded to receive the threaded portion, B 3, of the dome, B. After this has been done the long central hole for the spindle, E, should be drilled. This should be a 17-64 inch hole, to be drilled of

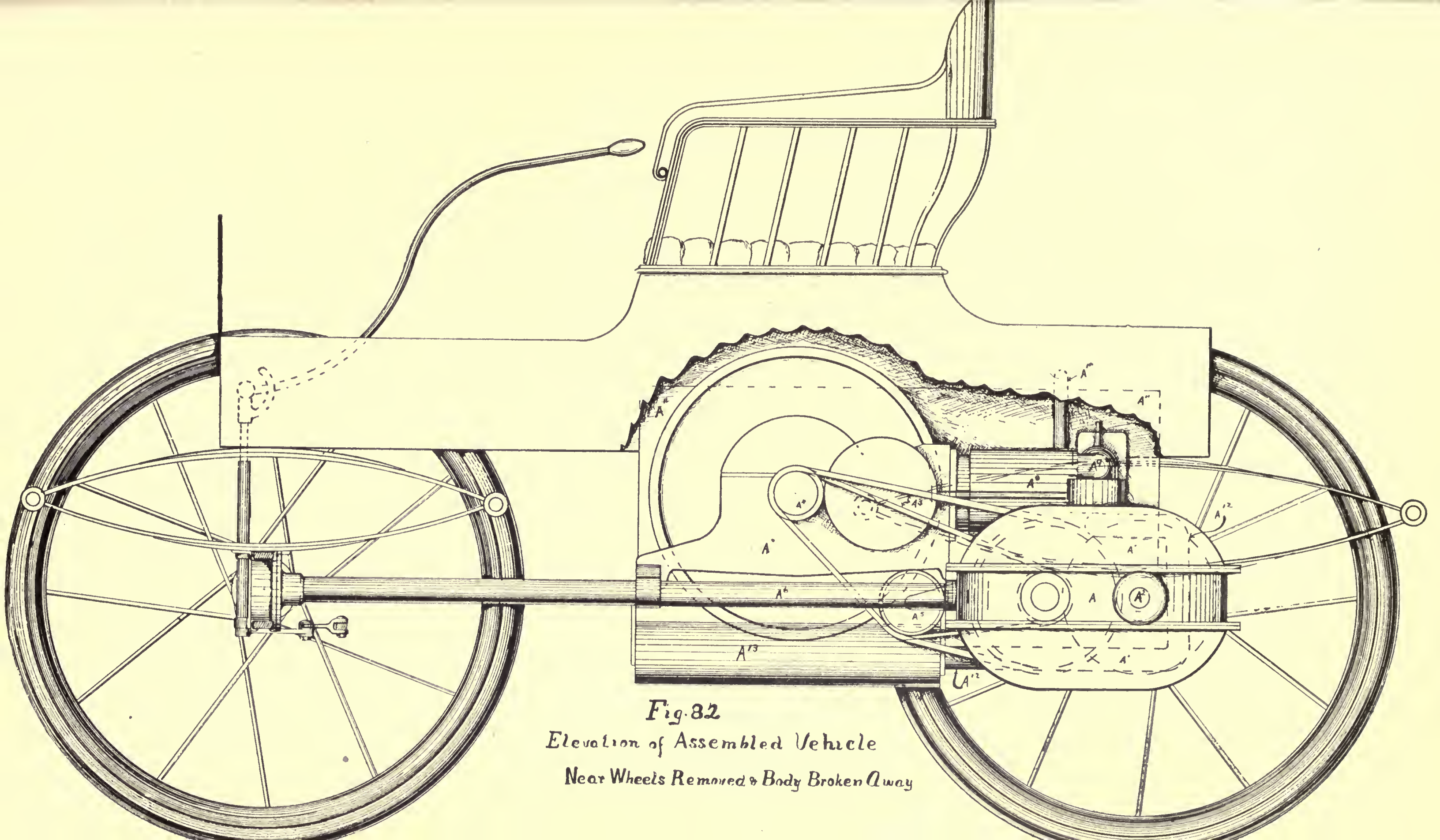


Fig. 82
Elevation of Assembled Vehicle
Near Wheels Removed & Body Broken Away

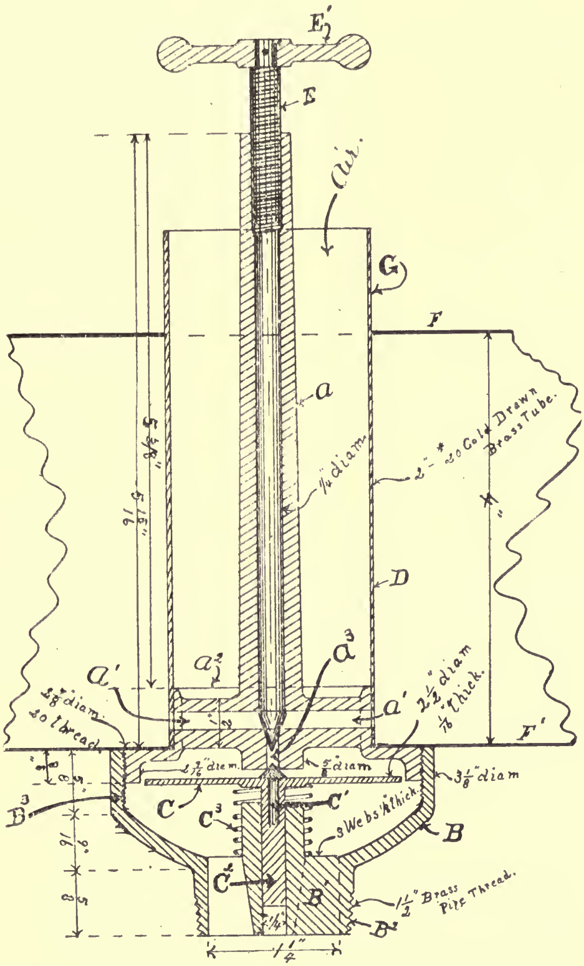
sufficient depth to intercept a 3-16 hole, which is to be hereafter drilled through the center of the two arms, a 1. The top end of, a, should be tapped as shown. After the above machining has been done, the surfaces of a 2 that contact with the tube, D, and with the bottom of the gasolene supply tank, F 1, should be carefully tinned, as should the inner wall of the tube, D, at its lower end. The tube, D, should then be sweated onto the ring, a 2. The 3-16 inch holes may now be drilled through the tube, D, and the arms, a 1.

This dome consists of an outside shell, B, having a tubular extension, B 2, at its lower end, and a central boss supported from the inner walls of B 2 by three wings, B 1. This boss should have a 1-4 inch hole drilled through its center. This hole should be drilled while the piece is in the chuck, being threaded at B 3 to screw onto A, thus insuring its being true with this threaded part. The outer pipe thread, B 2, may now be cut. This is a standard 1 1-2-inch pipe thread, plumber's size.

The dome, B, may now be screwed onto the piece, A, and the hole, a 3, may be drilled by means of a special drill having a shank to fit the 1-4 inch hole in the central boss of B. The lower seat of a 3 may now be formed by passing a suitable tool through the hole, c 2, so as to have the seat true with this hole. After doing this, the seat for the valve, E, may also be formed in a similar way by passing a tool down through the long hole in, a, and reaming a suitable seat at the upper end of the hole, a 3.

The baffle plate, C, is turned up from a steel or brass casting (preferably the former) and the hardened valve head, c 1, driven into place as shown. The stem, c 2, should be an easy fit in its guiding hole. A spring, c 3, should now be wound of about 24 gauge piano wire, of such a length as to hold the baffle plate valve, c 1, against its seat with a pressure of a few ounces. Adjustment may be had by means of the screw thread, B 3.

The top and bottom of the tank are shown at, F and F 1, showing the manner in which the completed atomizer is soldered into the tank. It will be evident, assuming that the atomizer has already been soldered into the tank and that the latter is filled with gasolene, that if the valve, E, is opened the gasolene in the tank will run through the two holes, a 1, and down the passage, a 3, until it is stopped by the valve, c 1. This valve being carried by the baffle plate, C, allows a flow only on the suction stroke when the air is supplied to the cylinder through the tube, D, as indicated.



On starting an engine using this atomizer, it will be necessary to depress the baffle plate, C, for a moment, in order to allow a small preliminary charge of gasolene to flow over the parts. so as to moisten them. The valve will not work readily unless this is done.

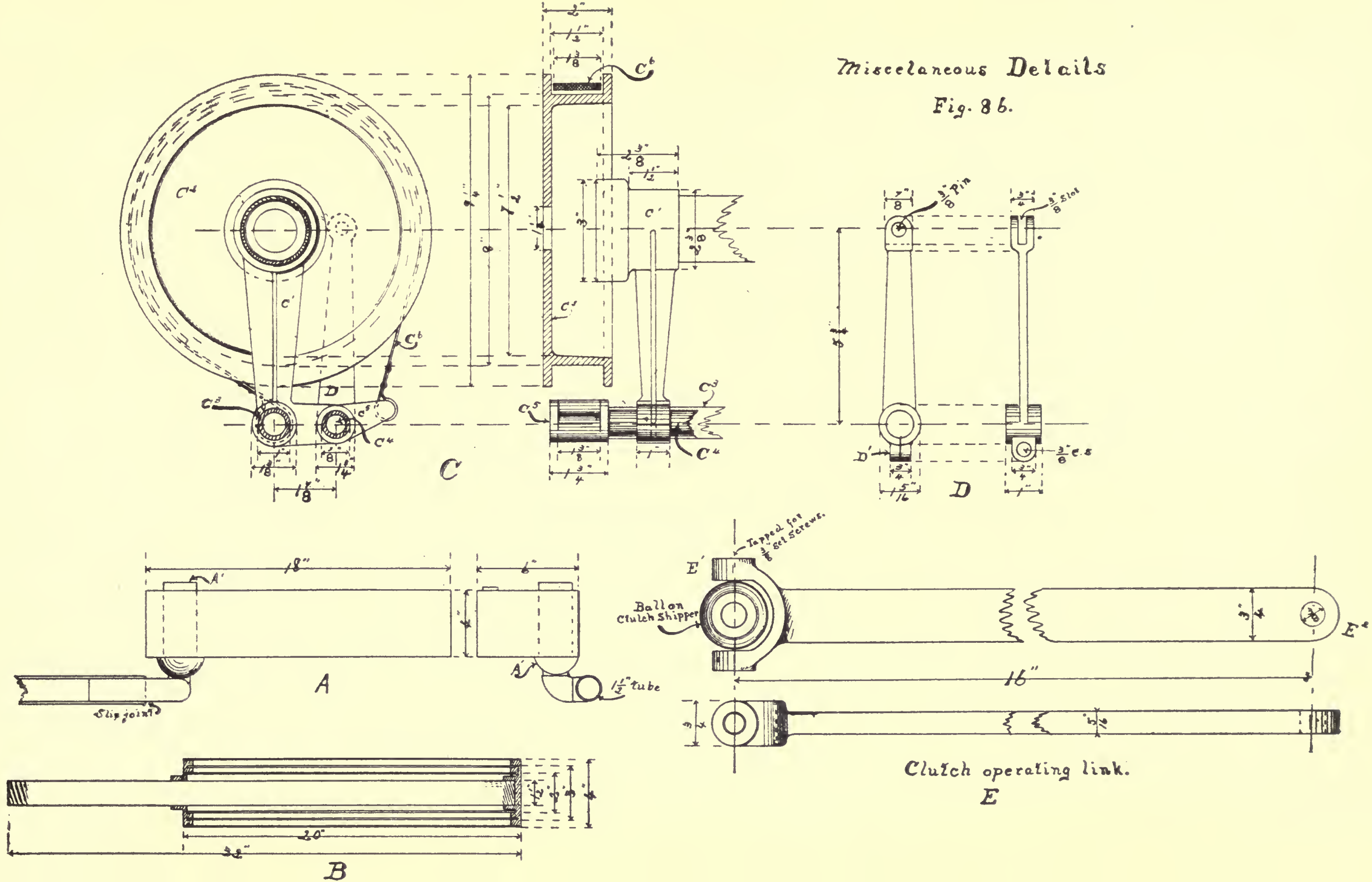
In figure 86, at A, we show the complete gasolene supply tank with the atomizer described in our last chapter soldered into the tank at A′. This is clearly shown in both elevation and end view. The method of connecting the atomizer to the inlet valve is also clearly shown, and it will be noticed that the double elbow connection, together with the slip joint, will compensate for all the variations in the relation of these parts due to the springing of the vehicle body.

At B, figure 86, is shown the muffler, which consists of four tubes, the inner one measuring 1 1-2 inches outside, the next one 2 inches, over which is a 3-inch and then a 4-inch, which forms the covering of the muffler. These tubes are concentric, as shown, and the walls of each are pierced with a number of small holes at alternate ends and on opposite sides of the tubes. There should be 65 1-8-inch holes in each tube and they should not run around the tube more than one-third circumference. These tubes can be made of common heavy Russia iron rolled up and clinch-jointed, or they may be made of copper, all except the inner one, which must be of iron or steel, on account of the great heat it is subjected to.

In figure 86, C illustrates the brake mechanism in elevation and section. In this figure c′ is the ball bearing cup end of the rear axle. This piece was shown in figure 83. The lower end of c′ terminates in the boss which carries the tube, c 3, also shown in figure 83. This tube, c 3, projects sufficiently beyond the boss of c′ to receive the brake band, c 6, the other end of this brake band is secured to the rocker-arm, c 5. This rocker arm, together with its mate, are tightly fitted onto the rocker-shaft, c 4, onto which is also clamped the lever, D, shown in dotted lines in C and at D. The brake band, c 6, surrounds the brake drum, c 2, which should be securely attached to the hub of one of the driving wheels, while a similar drum is to be attached to the other driving wheel. The band, c 6, is composed of a piece of 16 gauge spring steel, 1 1-2-inch wide, to which is securely riveted a leather strap, as shown, and as is customary in band brakes for all purposes.

Miscelaneous Details

Fig. 86.



The steel tube, or rod, c 4, is sufficiently long to reach from one brake to the other, and the lever, D, is placed between the two rock-levers, c 5, in such a position that the link connecting the upper end of D with the foot lever, will pass between the cam shaft gear and the motor casing. It will be understood that the ear, D′, shown on the brake lever, D, is cut through its center with a 3-32-inch saw, as shown. One side of the ear is drilled a clearance for a 3-8-inch cap screw, while the other half of the ear is tapped for same. In this way a very effective clamp is formed. The lever, D, should be of a good quality steel casting, as should the rocker-arm, c 5.

The relative position of the lever, D, to the rocker-arm, c 5, is shown at c, where the manner of fastening the brake band, c 6, to the rocker-arm, is also clearly shown.

The clutch-operating link, E, figure 86, connects the clutch shipper, previously shown, with the operating or hand lever which controls the clutches from the seat. The forked end, E′, of the clutch operating link, embraces the ball on the end of the clutch-shipper are shown. The two embracing arms are tapped for 3-8 inch cap screws, the conical ends of which enter counter-bored holes in the ball, thus forming a simple form of ball and socket joint which will allow for the springing of the vehicle body and the circular motion of the clutch shipper. The end of E 2 of the clutch operating link is carried by the lower end of the controlling lever which is itself supported by the carriage body, as will be shown in a sketch. The clutch operating link, E, may be cast of malleable iron or brass, as it has but little work to perform. Brass will be best if it is to be nickel plated.

There are many small details, such as the foot pedal of the brake and the tiller for steering, etc., that will not be described in this book, because there are so many different samples of them constantly before us that all the necessary information regarding them is probably already acquired by those contemplating doing any motor vehicle construction or repair work.

We shall dismiss the body construction with but a few words, because it will be much cheaper for any builder to have a regular body manufacturer build his bodies, instead of doing so himself. Further, as the body in the design of vehicle we have described in this book has no greater strains imposed upon it than has the ordinary horse-drawn vehicle, anything in the body line will do. The style may be varied to suit the fancy, provided, of course, the weight is kept low.

Another feature that will be found advantageous, will be the operating of the gasolene feed valve of the atomizer from the seat. This can be easily done by fixing a bevel gear onto the spindle of the valve in the place of the small hand wheel shown. This bevel gear to be so arranged as to mesh with a second similar bevel on a horizontal shaft reaching forward through the fall of the carriage. The hand wheel may be placed on this forward end of the horizontal shaft, so as to be easily reached from the seat.

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