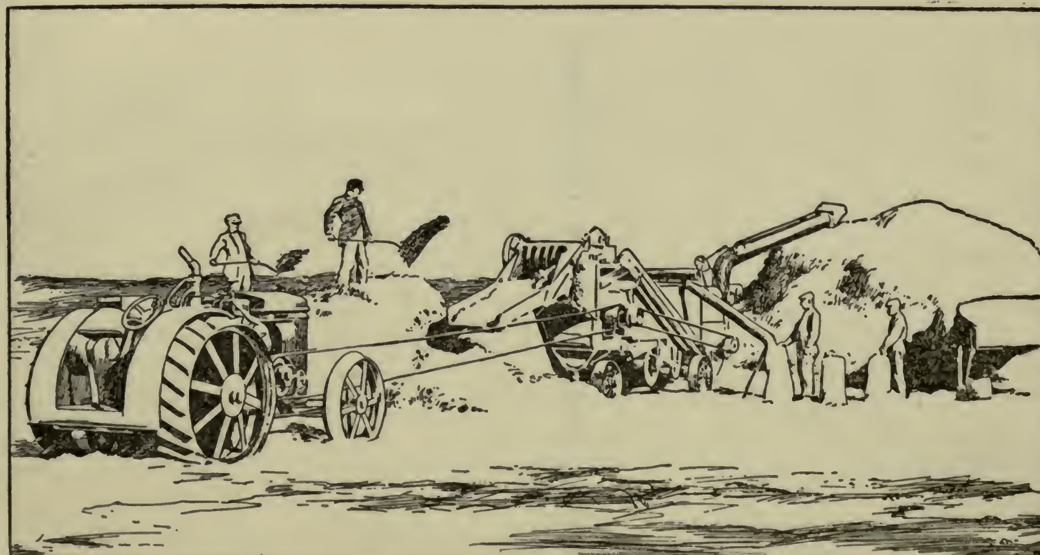
D GARDEN TRACTORS

A. FREDERICK COLLINS

FARM AND GARDEN TRACTORS



A Belt Power Application of the Tractor

FARM AND GARDEN TRACTORS

HOW TO BUY, RUN, REPAIR AND TAKE CARE OF THEM

BY

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WITH NUMEROUS ILLUSTRATIONS AND DIAGRAMS

NEW YORK

FREDERICK A. STOKES COMPANY

PUBLISHERS

TO

LLOYD VAN GORDER

WITH THE APPRECIATION OF
THE AUTHOR

A WORD TO YOU

The problem of farming to-day is how to raise bigger crops per acre and at the same time reduce the number of men and lower the cost of production.

The answer to the problem is to use (1) the proper fertilization methods, and (2) the right kind of farm machinery. Of the latter the tractor is by all odds the most important factor in securing the desired results.

It is not enough however to simply buy a tractor and put it to work in the field. The size of your farm as well as your bank account will determine very largely the size of the tractor you want. And having determined the size you must be exceedingly careful of the kind of a tractor you buy and having bought it of the way it is used and looked after.

While the day of the gas pipe and cast iron tractor is past still the design and construction of tractors is not at all fixed, or *standardized* as it is called, and to make a tractor of any size pay on a farm of any kind it must be designed right and then built right. When you have bought such a tractor the next thing to do is to get tillage and cultivating implements and harvesting machinery that are made especially for tractor work. Then a most important feature in the economical use of the tractor is to know how to run it and how to take care of it as well as the implements and machinery that are used with it.

It may seem as though it is asking too much of the farmer to invest in a complete tractor outfit and to learn all about it but to make a success of farming in these days the right kind of an equipment is vitally necessary and the management of the farm must be along approved scientific lines.

How to buy as well as how to use and take care of a tractor is told in this book and by following the precepts which I have laid down you will have small trouble in doubling, nearly, the output of your crop per acre, everything else being equal.

A. FREDERICK COLLINS.

The Antlers,
Congers, N. Y.

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CHAPTER I

ABOUT TRACTORS IN GENERAL

THE development of the *internal combustion engine,*[1] as that type of engine is called in which the fuel is fired directly in the cylinders, has given rise to many remarkable and highly useful vehicles such as the motor car, the motor truck, the motor boat, the airplane, and, finally, the *tractor.*

What a Tractor Is.— The word *traction,* as you probably know, means the act of drawing or pulling along and, hence, the word *tractor* has come to mean a self-propelled vehicle that is used primarily to pull a plow, a harrow, a cultivator or other farm machinery necessary in tilling the soil.

Since, however, the internal combustion engine is employed as the motive power for driving a tractor, it naturally finds a wide application as a power plant for all kinds of belt work, such as grinding feed, driving a threshing machine, operating a corn sheller, an ensilage cutter, a hay press, etc.

[1] All gas, gasoline and oil engines are internal combustion engines.

Types of Tractors.— Generically there are only two types of tractors and these are (1) the *steam engine* tractor, that is a tractor driven by a steam boiler and engine, and (2) the *internal combustion engine* tractor, or tractor which is driven by a gasoline or an oil engine.

Since the latter type of tractor is a more recent development and is at once safe, efficient and flexible it has all but supplanted the former type, consequently it is the only type of tractor that I shall tell you about in this book.

Of internal combustion engine tractors there are two classes and these are (A) *garden tractors,* and (B) *farm tractors.* The only difference in these machines is simply that with the first kind the operator *walks* while the second kind is large and he *rides.* Finally some tractors have for their traction members (a) *wheels* or *drums,* while others have (b) *track laying crawlers,* and this is the most striking visual difference in their make-up.

Specifically there are more designs of tractors than you can shake a stick at for, different from motor cars and motor trucks, the design of tractors has not yet been *standardized,* that is it has not been fixed to conform to a definite type.

Of course every tractor has a power unit in it and means for transmitting the power of the engine to the traction members; but the location of the engine, the number and disposition of the wheels or crawlers, the final drive and numerous other features of design are scarcely alike in any two makes of tractors.

How Tractors are Rated.— There are, however, a number of ways by which tractors are *rated* and this makes it easy to draw a *comparison* between those of different makes and sizes. Named these ratings are (1) the *belt horse-power;* (2) the *draw-bar horse-power;* (3) the *traction speed;* (4) the *weight of the tractor,* and (5) the *plowing capacity of the tractor.*

Horse-Power Defined.— The power of an engine is measured by the *number of pounds* that it can lift *one foot per second.* The *unit of power* was gotten up by James Watt and is called the *horsepower* (written H. P.) and this is the unit that is ordinarily used in engine practice to-day. *One horse power* = 550 foot-pounds per second or 33,000 pounds per minute.[1]

The Belt Horse Power of a Tractor.— This is the power of the engine that is developed at the pulley when it is used for running grinding mills and other farm machinery.[2] The belt horse power rating is usually about 80 per cent. of the horse power that the engine is guaranteed to deliver by its maker. This rating is understood to hold only when the engine is in good order and is running at its *rated speed.*[3]

The belt horse power of a tractor engine is, of course, always larger than the draw bar horse power, in fact it is usually about twice as large. Thus when you see a tractor rated at 1¼ to 4, 4 to 8, 12 to 24, 16

[1] The way to figure the horse-power of a tractor, or other internal combustion engine will be found in the *Appendix,* Page 269.

[2] How to find the belt horse power is explained in the Appendix.

[3] This is the speed given by the makers as being the one at which the engine runs most efficiently.

to 30, *et cetera, et cetera,* you will know that the first number is the horse power of the draw-bar pull, and that the second number is the horse power of the power take-off of the belt pulley.

The Draw-Bar Horse Power of a Tractor.— The draw-bar horse power is the *pull* measured in horse power that a tractor is capable of developing at the draw-bar. The *standard draw-bar rating* [1] is 80 per cent. of the horse power that the maker guarantees is developed at the draw-bar when the tractor is run for two hours straight.[2] Again it is understood that the tractor is in good order and that the engine is running at its rated speed. Tests to determine the draw-bar horse power should be made on firm ground or sod so that the traction members will not slip.[3]

The Speed of Tractors.— While the *Society of Automotive Engineers* has determined that the most efficient speed for *plowing* is 2⅓ miles per hour for tractors of 15 draw-bar horse power and under, tractors are so designed and built that they can be run at varying speeds from 0 + up to 5 miles an hour, that is, each individual tractor can be adjusted to meet the running conditions imposed upon it.

The Weight of Tractors.— Tractors weigh anywhere from 530 pounds which is the *Beeman Garden*

[1] This is the standard of the *Society of Automobile Engineers.*

[2] These tests are made with a *tractor dynamometer*, a full description of which, together with the way to use it will be sent you *gratis* on request by *The Tractometer Company*, Santa Fé and Slauson Aves., Los Angeles, Cal.

[3] The way to calculate draw-bar horse power is given on Page 210. See also *Draw Bar Pull of a Tractor at Various Speeds*, Page 271.

1¼–4 H. P., tractor on up to 30,000 pounds which is the *Nichols and Shephard Company's Oil-Gas,* 35–70 H. P., tractor.

The 5–10 H. P., up to 9–18 H. P., tractors range in weight from 2,450 pounds to 3,000 pounds; the 10–18 H. P., up to 14–28 H. P., tractors weigh from 3,300 pounds up to 5,000 pounds; the 15–22 H. P., up to 6–32 H. P., weighs from 4,400 pounds up to 7,800 pounds; the 17–35 H. P., up to 18–36 H. P., weighs from 5,300 pounds to 6,500 pounds; the 20–30 H. P., up to 25–40 H. P., weighs from 6,400 pounds up to 13,000 pounds; the 30–50 H. P., up to 40–75 H. P., weighs from 13,000 pounds up to 28,000 pounds; the 40–60 H. P., up to 60–90 H. P., weighs 18,700 to 28,000 pounds, and, lastly, the 70–120 H. P., tractors weigh in the neighborhood of 30,000 pounds.

The Plowing Capacity of Tractors.— The simplest, if not the most accurate, way of determining the capacity of a tractor to do the work you want it to do is to know how many plows it will pull.

For plowing *small plots* a garden tractor that pulls a single 12-inch plow is large enough. For *truck farming* you will need a tractor that will pull *one* 14-inch plow. For an *ordinary size farm,* say up to 160 acres, you will need a tractor which will pull *two plows,* while for a *big farm,* that is to say one of more than 240 acres, you want a tractor that will pull *three* or *more* plows.

A tractor rated at from 1 to 4 draw-bar H. P., will pull *one* 12-inch plow, one of 8 draw-bar H. P., will pull *two* 12-inch plows, while a 10 draw-bar H. P., tractor will easily pull *two* 14-inch plows and *three* 14-inch plows can be used at times. A tractor rated at 12 draw-bar H. P., and there are nearly fifty makes to choose from, will pull *three* 14-inch plows, though in my humble opinion a tractor of this horse power will do better when pulling two 14-inch plows in most soils.[1]

A 15 to 20 draw-bar H. P., tractor is best adapted to pull *three* 14-inch plows, though sometimes *four* plows are used. Tractors rated at 16 draw-bar H. P., will pull *three, four* and even *five* 14-inch plows, the number, of course, depending on the kind of soil, while for some of the 20 horse power tractors the makers recommend *six* 14-inch plows. A tractor rated at 22 to 26 draw-bar H. P., will pull *five* or *six* 14-inch plows while a tractor of from 30 to 38 draw-bar H. P., will pull from *five* to *eight* 14-inch plows, and, finally, tractors above this draw-bar horse power rating will take care of from *eight* to *twelve* 14-inch plows.

The Normal Draw-bar Pull in Pounds.—When the tractor is used to haul loads or do other draw-bar work it is well to know what the *normal draw-bar pull in pounds* is. By *normal* is meant the number of pounds that the tractor is rated as being able to pull with the most efficient traction effort. The following

[1] There is no hard and fast rule as to how many plows a tractor can pull for the reason that soils vary greatly and they are much affected by moisture.

table gives roughly the normal draw-bar pull in pounds of tractors ranging from 1 to 70 draw-bar horse power.

TABLE OF NORMAL DRAW-BAR PULL IN POUNDS

Draw-bar H. P., of Tractor	*Belt H. P., of Tractor*	*Normal Draw-bar Pull in Pounds*
1	4	200
5	10	900
8	16	1,200
12	20	2,150
18	36	3,100
25	50	5,000
30	60	6,000
40	80	10,000
70	120	12,600

The Length, Width and Height of Tractors.— The total length of a tractor, or *overall length* as it is called, means its length measured from its foremost to its hindmost point. The width of a tractor is not apt to be of much importance but the length of it may

TABLE OF TRACTOR DIMENSIONS

Trade Name of Tractor	*Draw-bar and Belt Horse Power*	*Length in Inches*	*Width in Inches*	*Height in Inches*
Beeman	1¼–4	86	17¼	39
Automotive	12–24	96	62	52
Short Turn	12–25	96	82	66
Creeping Grip	12–25	113	75	72
Yankee	12–25	126	71	58
Hollis	12–25	141	108	67
Lombard Tractor Truck	10–	144	78	72
Yuba	20–35	185	55	55
Linn Tractor Truck	20–35	192	64	90
Caterpillar	70–120	252	104	120

greatly affect its turning radius. The length, width and height of tractors vary greatly not only in different makes but according to their horse power ratings as the table on *Page 7* shows.

The Height of the Draw-Bar.— The draw-bar is often swivelled so that it can be adjusted vertically within narrow limits. The height of draw-bars from the ground ranges from 6 inches, as in the Bull Tractor Corporation's *Big Bull* tractor, to 24½ as in the *Case* 20–40. In those tractors that have adjustable draw-bars the vertical distance varies from 2 inches as in the Beeman *Model F,* to 12 inches as in the Blumberg *Steady Pull* 12–24.

The Clearance of Tractors.— The road *clearance* in tractor parlance means the vertical distance between the lowest part of the tractor, barring the traction members, namely, the wheels or crawlers, and the ground, and it is measured in inches. The clearance in some tractors is as little as 6 inches and in others as much as 22½ though in most of them it is between 10 and 15 inches.

The Sizes of Traction Members.— *The Face and Diameter of Non-Drive Wheels.*— As the small wheels of a tractor are not always the steering wheels they are called *non-drive wheels* in order to cover them all under one classification. The face of the non-drive wheels may be anywhere from 4 inches wide as in the *Coleman, Frick, Fargeol* and *Automotive* tractors up to 24 inches wide as in the single wheel *Tracklayer* 75.

The Face and Diameter of Drive Wheels.— The face of the drive wheels of tractors may be as little as 3 inches wide as in the *Merry Garden Auto-Cultivator,* or as much as 30 inches across, as in the *Minneapolis 60* and half a dozen other large tractors.

The diameter of the drive wheels range from 20 inches (1⅔ feet), as in the *Automotive*, up to 90 inches (7½ feet), as in the *Aultman-Taylor 30–60*. The majority of tractors, however, have drive wheels

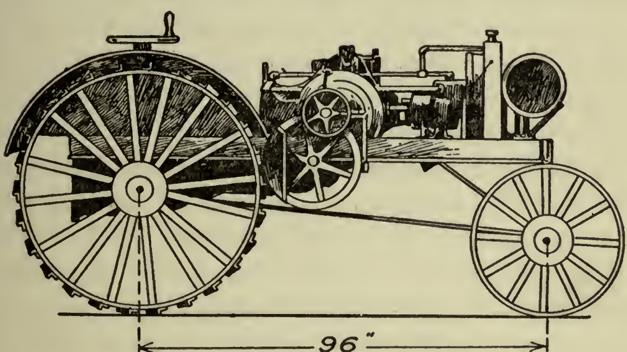


FIG. 1.—THE WHEEL BASE OF A TRACTOR

whose diameters are between 40 and 70 inches. The reason large wheels are used instead of smaller ones will be found in *Chapter XII*.

The Wheelbase of Tractors.— The *wheelbase* of a tractor is the distance from the center of the hub of a front wheel to the center of the hub of a rear wheel, as shown in *Fig. 1*. Why a long wheel base is desirable will also be explained on Page 262. The wheelbase varies in different tractors, the shortest being about 16 inches in the *Merry Garden Auto Cultivator* and 168 inches in the *Twin City* 60. The wheelbase lengths used in most tractors run from 75 to 100 inches.

The Face, Length and Area of Crawlers.— Like wheel traction members, crawlers are of all widths and lengths and, consequently, their traction surface areas vary within wide limits according to the ideas of their respective designers and the size of the tractors they are used on. Thus it is that the width of the face of a crawler is as small as 7 inches, as in the *E. F. T.* 15–30, and as large as 24 inches as in the *Tracklayer* 75.

The lengths of the crawlers vary all the way from 13½ inches as in the *Elgin* 10–20, to 153 inches in the *Leader C,* 18–36. The smallest surface area used in a tractor crawler is found in the *Hicks* 12–25, which has only 334 square inches, and the largest surface area is had in the *Tracklayer* 75 which has 3,700 square inches. The difference in the traction resistance in drive wheels and crawlers will be taken up in *Chapter XII.*

Percentage of Weight on Driving Members.— The proportion of weight of the tractor that bears on the drive wheels, or crawlers, varies in the two types of machines as well as in the same type of different makes.

In two wheel garden tractors like the *Beeman* and *Atlantic Cultivator* the full weight of the tractor, *i. e.,* 100 per cent., falls on the drive wheels. In the *Allis-Chalmers General Purpose,* the *Universal A*-19, 1–4, the *Princess Pat VI,* 10–20, and the *Trenan* 12–24, tractors all of which have two large drive wheels and one small support wheel, 90 per cent. of the weight is carried by the former.

So, too, in the *Aultman-Taylor* 30–60, the *Automotive* 12–24, the *Short Dill* 26, and the *Hollis* tractors, which are equipped with four wheels, 90 per cent. of the weight rests on the drive wheels, while in the *Power* 15–30, which is a four wheel tractor, 95 per cent. of the weight falls on the drive wheels.

In practically all other tractors having wheeled members the weight on the drive wheels is from 50 to 88 per cent. of the weight of the tractor but with the larger number of machines the weight is from 60 to 66 per cent. of the total tractor weight. Where crawlers alone are used the weight carried by them is of course 100 per cent. of its weight of the tractor.

Range of Speed and Gear Ratios.— The speed of a tractor depends on three chief factors and these are (1) the speed the engine is running at, (2) the size of the drive wheels, and (3) the *ratio of the transmission gears,* which means the size of one gear connected with the crankshaft of the engine, with the size of another gear that finally connects with the drive wheels.

High gear ratio means that the engine crankshaft is connected to the drive wheels through the transmission gears so that the tractor will travel at its greatest speed. Hence, the speed of the engine shaft is reduced only a small amount in relation to the spiral drive shaft and the drive wheels.

Suppose that the *high gear ratio* as given by the makers is 70: 1; now when the large gear of the transmission is thrown into mesh with the small one of the transmission the difference in the size of gears is very small and this gives the tractor speed at the sacrifice of power.

Low gear transmission is just the reverse of the above, to wit, the engine crankshaft is connected to the drive wheels through the transmission gears so that the tractor will travel at its slowest speed. Now the two gears in mesh vary greatly, the small one being connected to the engine shaft and the large one to the drive shaft or rear axle and wheels.

As an example, if the low gear ratio is 97: 1 when the small gear of the transmission, which is connected to the engine, is thrown into mesh with the large one, the engine will have a speed 97 times as great as that of the drive wheels. This gives the tractor power at the expense of speed.

The Turning Radius of a Tractor.—The term *turning radius* of a tractor means the *radius* of the smallest circle, measured in feet, in which the tractor can turn completely around. The radius of this circle, or *turning radius* as it is called, is found as follows:

Turn the front wheels of your tractor to the right or left as far as they will go and the turning radius will then be the radius of the circle whose circumference passes through the hub of the outer front wheel and whose center is at the hub of the inner rear wheel as shown in *Fig. 2*.

There are several factors that determine the size of the circle the tractor can turn in and these are (*A*) in *wheel tractors* (1) the length of the wheel base, (2) the number of wheels, (3) the disposition of the wheels and (4) the angle of the *arc* through which the front wheels turn.

Where (*B*) the tractor members are *crawlers* then

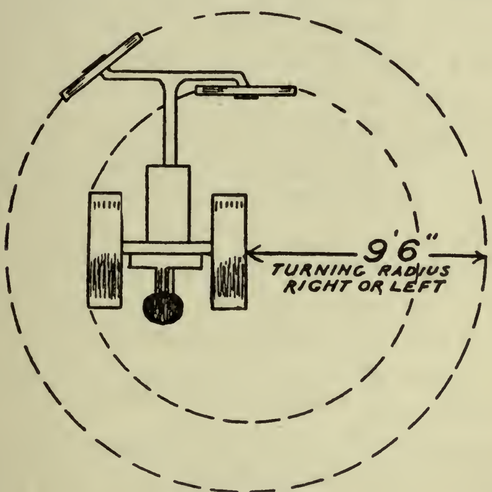


FIG. 2.—THE TURNING RADIUS OF A TRACTOR

the turning radius depends on (1) the length of the crawlers, (2) their distance apart, and (3) whether one of them can be reversed when a turn is being made. Thus a three wheel tractor usually has a shorter turning radius than a four wheel tractor of the same wheelbase while a four wheel tractor in which the front wheels are mounted on a pivoted axle cannot turn in as small a circle as one wherein the wheels are mounted on a knuckle axle.

Some tractors have a turning radius as small as 4 feet, as for instance the *Hollis, Model M, 15–25* and the *Short Turn 20–30,* that is to say either of these tractors can turn in a circle whose diameter is 8 feet; again, other tractors have a turning radius as large as 48 feet, as the *Ohio General, 15–30,* which means that the smallest circle it can turn in must have a diameter of 96 feet.

The Prices of Tractors.— You can buy a tractor such as the *Atlantic Garden Cultivator* for $185, or you can spend $6,250 for a *Yankee Ball Tread* tractor, or anything in between these amounts. Garden tractors cost anywhere from $185 for the *Atlantic Cultivator,* as above stated, to $465 for the *Auto-Tiller,* and the above tractors pull *one 4 inch* to *one 12 inch* plow, according to the price, and you have to walk behind them.

There are *four 14 inch* plow tractors in the market and these cost from $785 to $900 each but in every case they are provided with seats so that he who plows may ride. Of *two plow tractors* there are about 40 makes on the market ranging in price from $800 to $1,595. Of the next size tractor there are an even dozen styles and these are recommended to pull *two or three 14 inch plows* and cost from $1,200 to $1,800.

Three plow tractors are the favorite of the makers and, hence, it is a safe deduction to say of the buyers, for there are 65 makes of them and the prices run from $1,125 to $5,800 though the average price is, I should say, about $1,800. Of the *three to four 14 inch plow* tractors there are only 25 makes and these are sold at from $1,175 to $6,000 so that you have a great range in price if not so many makes to choose from.

Of the strictly *four-plow tractors* there are about a score, and the current prices of these are from $1,750 to $4,000. There are in the neighborhood of a dozen makes of tractors that pull from *four to five, four to six* and *four to twelve plows* and the average price is something like $3,000. And finally tractors that pull from *five to twelve plows* cost from $5,000 to $10,000 [1] each.

In Conclusion.— While the above explanations covering the *factors* of tractors are necessary in order to gather an intelligent conception of their general characteristics and hence have to do with the kind of a tractor you want, still there are other vital features which must be taken into consideration when you are ready to buy a tractor and these will be fully discussed in the last chapter.

[1] The prices all through this book are provisional and are given chiefly by way of comparison.

CHAPTER II

THE PARTS OF A TRACTOR

WHILE the design of tractors is by no means fixed still the individual parts of all of them are quite alike and whatever the make may be the construction of the different parts follows along the same general lines if we make occasional exceptions.

Now the easiest way to get a clear understanding of how tractors are built and work is to examine the various parts, see how they are made, what they are for and the rôles they play. This you can do better by first reading a description and looking at the pictures of them than you can by going over the tractor itself.

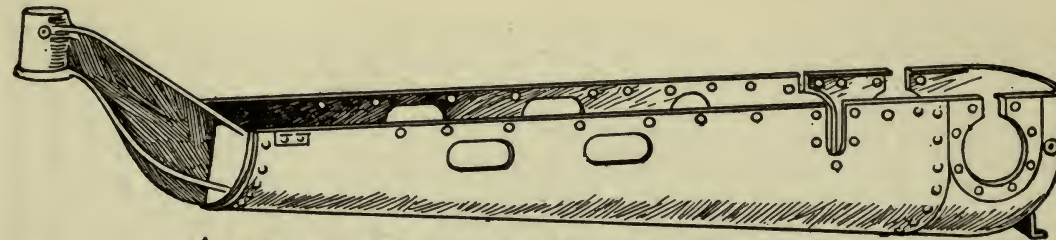
The Chief Parts of a Tractor.— A tractor of any kind is made up of the following principal parts, namely, (1) the *frame,* which is the foundation on and around which the tractor is built, (2) the *traction members,* as the wheels and crawlers are called, (3) the *power unit,* which includes the engine and all of its ancillary devices, that develops the power, (4) the *transmission system,* which transmits the power of the engine to the drive wheels or crawlers by various clutches, gears and shafts, (5) the *steering* *gear* by and through which the tractor is steered, and (6) the *braking devices* for stopping the tractor.

The Frame Comes First.— The frame is supported by the wheels or crawlers, and it, in turn carries the engine, the transmission system and all the other numerous parts that go to make up the tractor. Further, the frame must be sufficiently rigid so that all of the power units will remain fixed in their positions relative to each other.

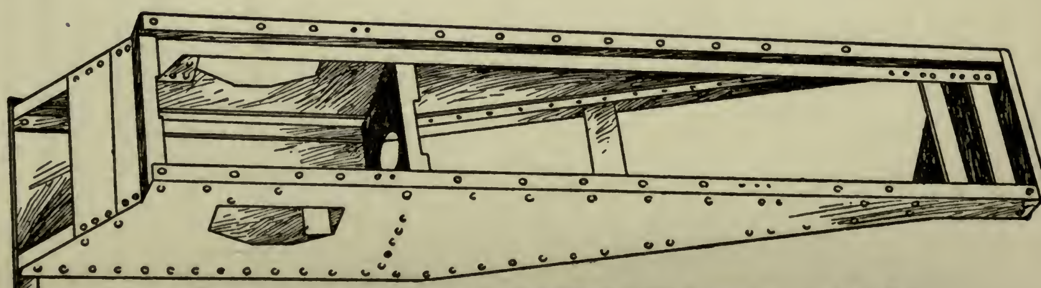
Now tractor frames are made in one of two ways, to wit, either (1) of one piece of steel, or they are (2) built up of structural steel. Where a frame is made of one piece it is either (a) cast in a mold, or (b) pressed of sheet steel, that is of *boiler plate,* but where it is built up it is formed of I girders or ship steel channels which are fastened together with hot rivets hammered down with a power riveter which applies a pressure of 75 tons to each rivet. A one piece pressed U-section frame of a *Willis* tractor is shown at *A* in *Fig. 3* and a built-up deep girder frame of a *Twin City* tractor is shown at *B*.

What a Three Point Suspension Means.— To enable the tractor to travel easily over rough ground and so prevent the power units from being jarred out of alignment a *three point suspension* is used.

A three point suspension means that the frame rests on *three points* and not on *four.* As an illustration take a four-legged table where one leg is shorter than the others; such a table will not stand evenly and will be inclined to rock; oppositely, a table with only three



A- THE WALLIS BOILER PLATE U-SECTION FRAME



B- STRUCTURAL STEEL FRAME OF THE TWIN CITY 40-65

FIG. 3.— TWO KINDS OF TRACTOR FRAMES

legs will always set firm though it may not set level.

The three point suspension scheme is used in the

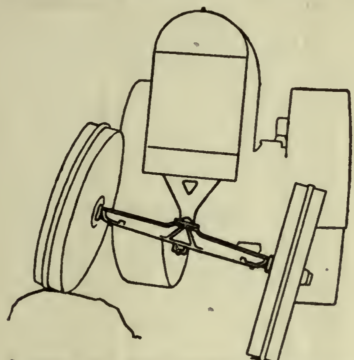


FIG. 4A.— KINDS OF THREE POINT SUSPENSIONS

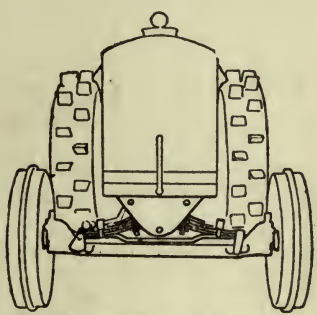


FIG. 4B.— KINDS OF THREE POINT SUSPENSIONS

construction of wheel vehicles of all kinds be it a wheelbarrow or a locomotive. In a tractor two of the points of suspension must rest on the rear axle near the hubs of the wheels and the third point of suspension rests on the middle of the front axle.

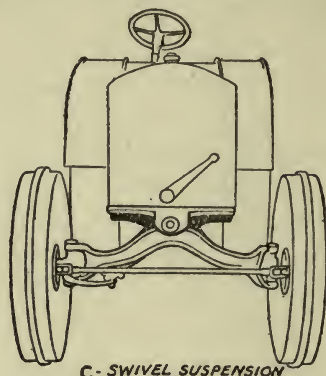


Fig. 4c.— Kinds of Three Point Suspensions

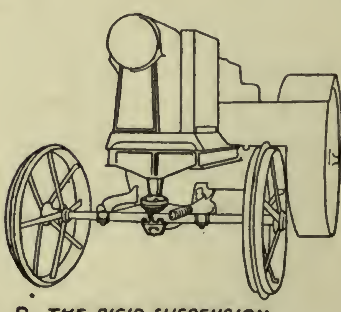


Fig. 4d.— Kinds of Three Point Suspensions

Kinds of Front Suspension.— The point that rests on the front axle, or *front suspension* as it is called, is either (1) a *ball and socket suspension,* (2) a *spring* *suspension,* (3) a *swivel suspension,* or (4) a *rigid suspension.*

In the ball and socket suspension a large ball which is fixed to the front end of the frame fits into a socket in the front axle as shown at *A* in *Fig. 4.* In the spring suspension the spring is mounted on the front axle and the front end of the frame is secured to the middle of it as shown at *B.*

Where a swivel suspension is used the front end of the frame is simply pivoted to the front axle as shown at *C,* while finally in the rigid suspension the front end of the frame is rigidly fixed to the front axle as at *D.*

The Draw-Bar.— The draw-bar is usually fixed to a cross brace on the frame, as shown in *Fig. 5,* that sets in front of the rear axle and it should have a coil spring suspension to allow it to give a little and to absorb the shocks. The coupler end sets well back of the rear axle so that plows and other implements can be easily and quickly hitched to it. In some tractors the draw-bar is (1) *rigid,* and in others it is (2) *pivoted* to allow it to move from side to side, while in a few it is (3) *swivelled* so that its height can be adjusted.

About the Axles of Tractors.— There are two axles used in tractors having four wheels,[1] or where a single, front, non-drive wheel, or a single, rear, non-drive wheel is employed the stub journal it sets on

[1] Except the *Post* tractor, which has four wheels but with one drive wheel in the front and one in the rear.

may be considered as the equivalent of an axle. There are two kinds of tractor axles and these are (1) the *non-drive axle,* and (2) the *drive axle.*

The Non-Drive Axle.— This is usually the front axle, though there are half-a-dozen tractors where it is the rear axle and in the *Post* it is the middle axle.

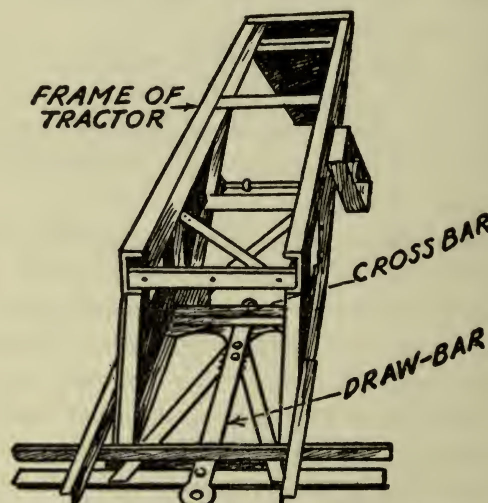


Fig. 5.— The Draw Bar on a Twin City Tractor Frame

Where it is either the front or the rear axle it is (1) made to turn on a pivot in the end of the frame, or it is (2) rigidly fixed to the end of the frame.

Where it turns on a pivot the wheels are mounted on and rotate around the ends of it, but where it is rigid and used for steering it is provided with knuckles on which the wheels are mounted and these allow them to swing either way. As these axle assemblies have to do with steering the tractor as well as to help support the frame, they will be more fully described in Part III of Chapter III under the heading of the *Steering Gear.*

The Drive Axle.— As this axle carries the drive wheels it must, therefore, always be at right angles to the line of traction; since this is the case it is rigidly attached to the frame. There are three kinds of *drive axles* that have found favor with tractor engineers, and these are, (1) the *dead axle,* (2) the *live axle,* and (3) the *stub axle.*

The *dead axle,* as it is called, is one that is rigidly fixed to the frame and, hence, does not transmit power to the drive wheels which revolve on its ends. Tractors whose drive wheels are driven by chains and bull-gears are of this type. A *live axle* is one that revolves and transmits power to the drive wheels but which runs in a hollow axle, or *housing,* and to the latter is fixed the frame of the tractor; live axles are used where the *differential gears*[1] are placed on a separate shaft.

Finally a *stub axle* is one that carries the differential between its opposed ends while the drive wheels are keyed to the outer ends. The stubs rotate in a hollow tube or housing and this is fixed to the frame of the tractor.

The Suspension Springs of a Tractor.— Some

[1] See *Part II, Chapter III,* for a description of the *Differential.*

tractors are provided with suspension springs but the larger numbers are not so equipped. Where springs are used they are either (1) *coiled springs,* (2) *semi-elliptic* springs, or (3) *platform springs.*

Some tractors have their frames mounted on (1) springs in front only, others have their frames mounted on (2) springs in the rear only, and a few have their frames mounted on (3) springs at both the front and rear ends.

The Traction Members of Tractors.— There are three distinct kinds of *traction members* used on tractors and these are (1) *wheels,* (2) *drums,* and (3) *crawlers, endless track, tracklayers,* or *caterpillars,*[1] as this last type is variously called, and, lastly, (4) there are divers combinations of wheels and crawlers used.

Wheel Traction Members.— Many tractors have three wheels only and this type is divided into those that have (*A*) two drive wheels in the rear and a single non-drive wheel in front, (*B*) two drive wheels in front which also serve to steer with, and a single non-drive wheel in the rear, and (*C*) two non-drive wheels in front and a single drive wheel in the rear.

But by far the larger number of makes of tractors have (*D*) *four wheels,* and some of these are driven by (*a*) the front wheels, the majority are driven by (*b*) the rear wheels, while a few are driven by (*c*)

[1] While tractors of the crawler type are often called *caterpillars,* the word *caterpillar* is the U. S. registered trade-mark of the *Holt Mfg. Co.,* Peoria, Ill., and, hence, it can only be properly applied to their tractors.

all four wheels. An outstanding tractor in the way of traction members is the *Wilson* which has *five wheels,* three of which are drivers at the rear end.

The Construction of Tractor Wheels.— The non-drive wheels are either (1) made of cast-iron, or (2) are *built up* of pressed steel rims and spoked with flat steel bars riveted to them.

Nearly all tractors use *drive wheels* of the built up

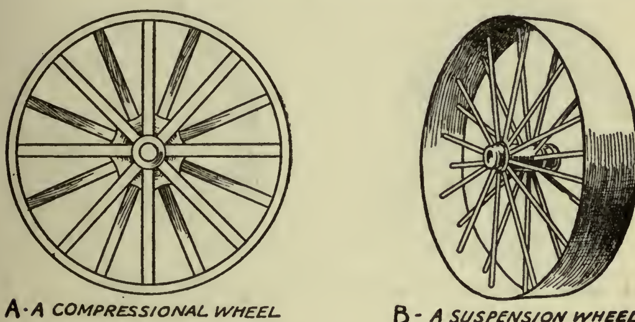


FIG. 6.— KINDS OF DRIVE WHEELS

type and of these there are two kinds, namely, (*A*) the *compressional* wheel and (*B*) the *suspension* wheel.

In the compressional kind the bars are riveted to the inside of the rim and to the outside of the hub as shown at *A* in *Fig. 6.* In this wheel the weight of the tractor rests chiefly on the two or three spokes at the point where the rim makes contact with the ground and hence the stress on the wheel is *compressional* like that on a wagon, or motor car wheel when made of wood.

In the suspension kind the spoke rods pass through and are fixed on the outside of the rim and are secured to the inside of the hub in the same fashion as the wire spokes in a bicycle, or other spoked wheel, as shown at *B*. Hence the weight is *suspended* from the top of the rim and the stress is consequently distributed on nearly three-fourths of the spokes. For this reason the suspension wheel is considered the best practice.

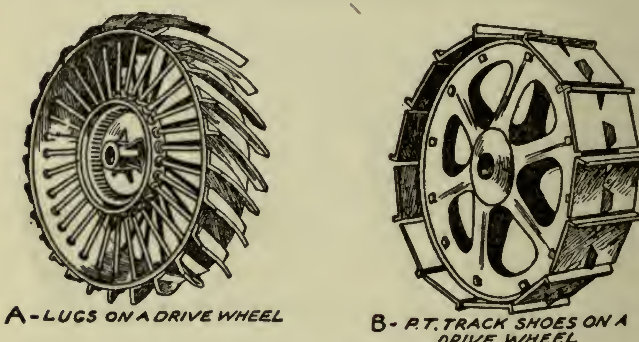
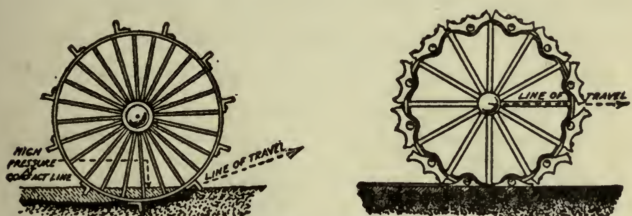


FIG. 7A, B.—DRIVE WHEEL GRIPS

The Lugs and Track-Shoes on Drive Wheels.—To keep the drive wheels from slipping in soft soil and to reduce the rolling resistance *lugs* and *pads,* or *track-shoes,* as the latter are called, are fixed to and on the rims as shown at *A* and *B* in *Fig. 7,* and in the first case they can be put on or taken off.

Where lugs are used the wheel tends to sink into the soft soil and then the *line of travel* is really uphill, as shown at *C,* and this adds to the power required to drive the tractor. To get around this untoward feature the pad, or track shoe, was devised and a number of them are either pivoted on and around the rim, as shown at *D,* or else they are hinged together in an endless series and set on the rim as at *B.* With either kind of track-shoe the wheel is converted into a semi-crawler, laying its own steel track so that there is no *digging in* and in which the travel is continuously in a straight line forward.



C-A LUGGED WHEEL GIVES AN UP-HILL LINE OF TRAVEL   D-GRIP PADS GIVE A LEVEL LINE OF TRAVEL

FIG. 7C, D.— EFFECT OF DRIVE WHEEL GRIPS

Drum Traction Members.— A couple of tractors use a wide drive wheel, or *drum,* at the rear, and like the single drive wheel, the drum does away with the *differential,* the construction of which is explained in the next chapter. The drum is driven by chains on the sides and they are provided with spikes or lugs. A wide drive drum gives, of course, a larger amount of traction surface area than a drive wheel.

Crawler Traction Members.— *How They Work.* — The principle involved in the *crawler* type of tractor is that of an endless belt running on a pair of pulleys. Different, however, from a belt running on pulleys wherein the bearings of the latter remain in the same relative positions, not only with respect to themselves but also with respect to the earth, both the drive wheels and the endless track of a crawler tractor move forward together and progressively, due to the traction resistance between the track and the ground.

The endless tracks used in crawlers are made of jointed steel plates which have grooves or holes in them at equal distances apart and the sprocket teeth on the rims of the drive wheels mesh with these just

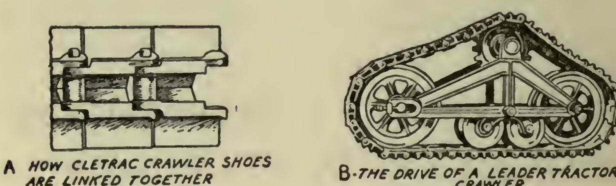


FIG. 8.— CRAWLER SHOES AND CRAWLERS

as they do in a sprocket and chain bicycle drive. From this you will see that the wheels themselves do not touch the ground but each plate, or shoe, as it comes in contact with the ground lays there until it reaches the rear wheel when it is picked up; and thus it is that a steel track is laid by the crawler for the tractor to run on.

How They are Made.— The construction of the crawler shoes and the way they are linked together is shown at *A* in *Fig. 8,* which is a top view of a *Cletrac* crawler track, while the way the endless track is driven by the sprockets is shown at *B*, which is a side view of a *Leader* tractor crawler mechanism.

Crawler tractors are very like wheel tractors in-so-far as the various parts are concerned, since it has a frame, traction members, engine and transmission system. Unlike the wheel tractor, though, very few crawler tractors have a *differential* but nearly all of them have *drive sprockets* and the power from the engine to the final drive shaft is, in nearly every make, transmitted and controlled by clutches.

The Power Plant of a Tractor.— To drive the traction members each tractor must have a *power plant* and this consists of (1) a *gasoline* or *an oil engine,* and includes the *power take-off,* (2) a *clutch,* (3) *transmission gears,* or *gear-set* as it is called, (4) a *differential,* usually but not always, and (5) the *final drive.*

As each of the above is a highly specialized piece of machinery that forms the very vitals of a tractor, and, consequently, which you ought to know all about, I will treat them separately and with due regard to detail in the next chapter.

Kinds of Bearings Used.— *What Friction Is.*— You have observed that when you slide one body over another the motion is opposed by a kind of resistance and this is called *friction.* Now friction is caused by the minute elevations and depressions of the opposed surfaces which interlock and it is further increased by the *adhesion* of those parts that touch the closest.

Now there are two kinds of friction and these are (1) *sliding friction* and (2) *rolling friction.* Sliding friction is much greater than rolling friction, though the latter is in evidence even when the surfaces are highly polished and this is due to both *cohesion* and *surface deformation* where the latter makes contact with the other body.

About the Bearings.— In tractors of both the wheel and crawler types three kinds of bearings are used

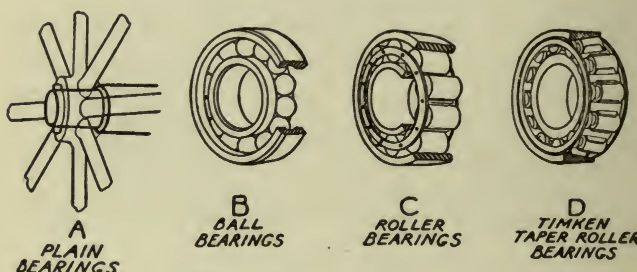


FIG. 9.— KINDS OF BEARINGS

to lessen the friction, and these are (1) *plain bearings,* (2) *ball bearings*, and (3) *roller bearings.*

In plain bearings a polished steel *pin* or *journal,* as the middle and ends of a shaft are called, respectively, is made to revolve in *babbitt* or *bronze* bearings. This is because it has been found that where two surfaces slide on each other — and the friction between a rotating journal and a stationary bearing is, obviously, *sliding friction* — if one of them is harder than the other the friction is less than where both are of the same metal. A plain bearing is shown at *A* in *Fig. 9.*

Since rolling friction is much less than sliding friction *ball bearings* and *roller bearings* are widely used in the various rotating parts of tractors. A ball bearing, see *B*, does not offer as much surface contact as a roller bearing and, hence, there is less friction than in the latter and these are always used for the smaller bearings. But where bearings must carry great stresses and strains roller bearings, as shown at *C* and *D*, stand up better.

The specifications of 165 different tractors chosen at random showed that there were 103 whose front axles have plain bearings, 55 that have roller bearings and 7 that are fitted with ball bearings, while out of the same number of tractors 72 have rear axles with plain bearings, 83 have roller bearings and 11 have ball bearings.

The transmission bearings, countershaft, intermediate shaft, differential, pulley and fan shafts of various tractors use (a) plain bearings, (b) ball bearings, and (c) roller bearings and these will be taken into account as we move along.

The Gears Used in Tractors.— Gears are made of seven kinds of metal, as the following list shows, and which also indicates their worth as far as service is concerned since they run from the poorest to the best. Named, these kinds are, (1) *cast iron,* (2) *cast steel,* (3) *common steel,* (4) *carbon steel,* (5) *crucible steel,* (6) *semi-steel* and (7) *alloy steel.* Alloy steel is one which usually contains a small per cent. of nickel or

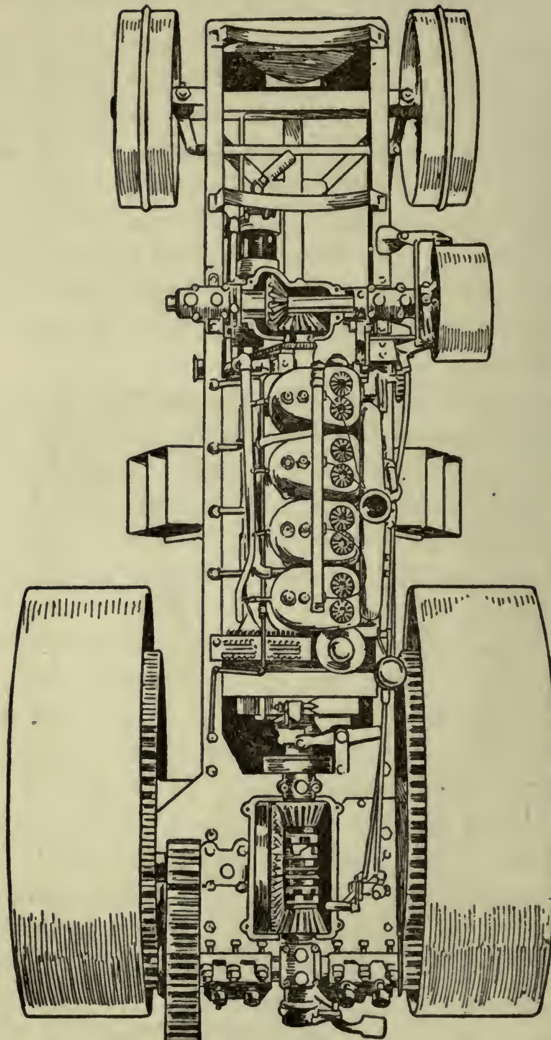


FIG. 10.— TOP VIEW OF A TWIN CITY 40–65 TRACTOR

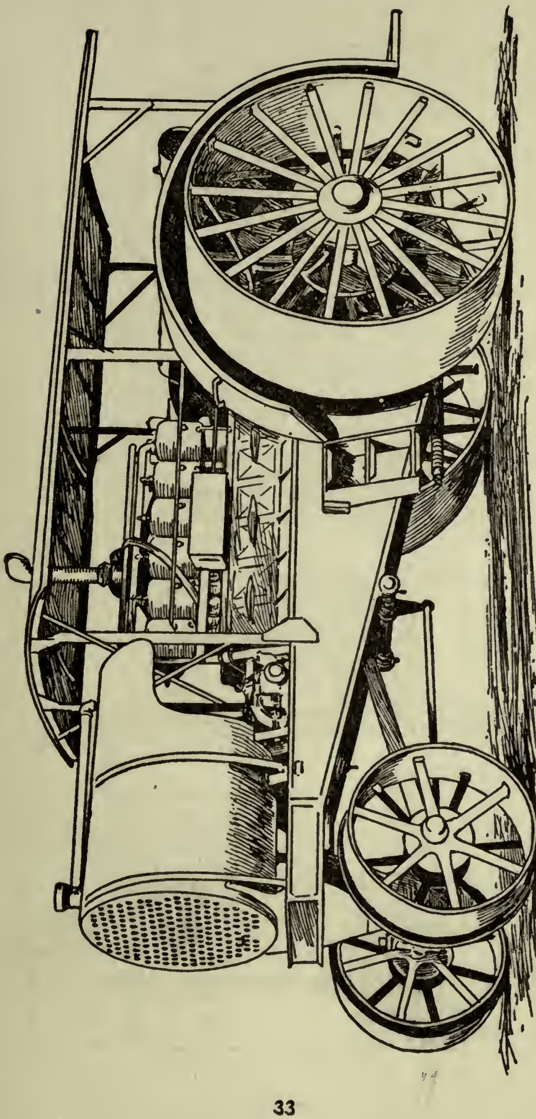


FIG. 11.— THREE-QUARTER VIEW OF A TWIN CITY 60–90 TRACTOR

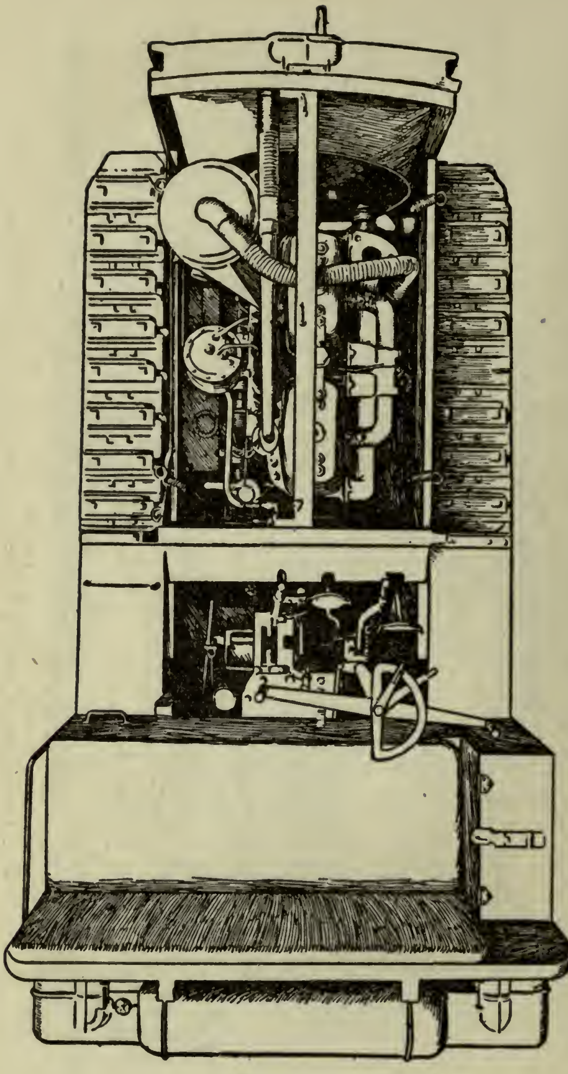


Fig. 12.— Top View of a 5-Ton Holt Caterpillar Tractor

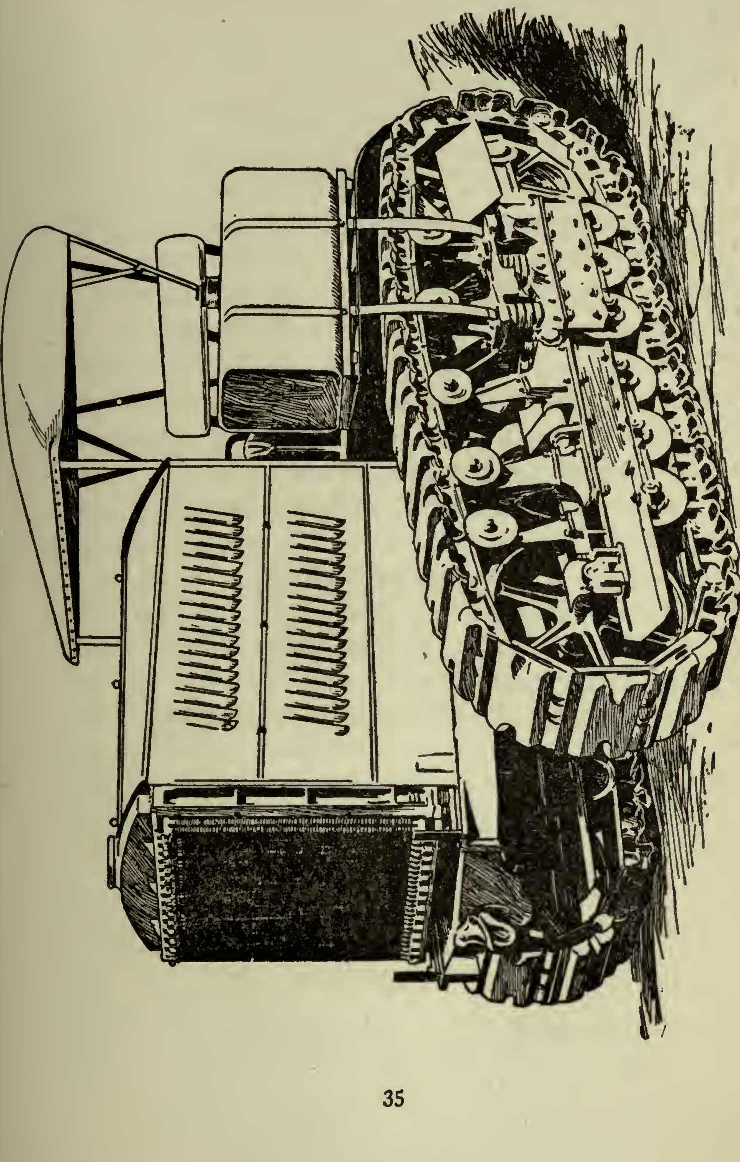


FIG. 13.— THREE-QUARTER VIEW OF A 10-TON CATERPILLAR TRACTOR

manganese and this makes it very tough and wear resisting.

Further gears are either (*A*) *cast,* or (*B*) *machined.* Where a gear is cast it cannot, of course, be as accurate or run as smooth as one that is machined, that is, one whose teeth are cut in a shaper. Finally, gears may be either (a) *case hardened* or (b) *heat treated.* In a case hardened gear only the outer surface is hardened, while in a heat treated gear the whole mass is tempered and retempered clear through and this provides a longer wearing gear. The *best gears* that can be made are formed of chrome-nickel or manganese steel, machined and heat treated.

Tractor Types Complete.— A top view of a *Twin City 40–65* tractor is shown in *Fig. 10,* and a three-quarter view of a *Twin City 60–90* tractor is shown in *Fig. 11.* Likewise a top view of a *5-ton Caterpillar* tractor is shown in *Fig. 12* and a three-quarter view of a *10-ton Caterpillar* tractor is shown in *Fig. 13.*

CHAPTER III

THE MECHANISM OF A TRACTOR

From the chapter that has gone before you have seen that the mechanism of a *tractor* of whatever make consists of four chief parts and these are (1) the *engine;* (2) the *transmission system;* (3) the *steering gear;* and (4) the *brakes,* and to do them justice I will describe them under three separate headings.

Part I

HOW THE ENGINE IS MADE AND WORKS

As I have previously pointed out all tractor engines are built and operate on the same fundamental principle whether they are formed of one or more cylinders. But to simplify matters, let's take a single cylinder engine and tear it down to get at the parts of it and then reassemble it to find out how it works.

The Parts of a Tractor Engine.— A tractor engine is made exactly like that of a motor car engine and, hence, is built up of the following parts: (1) the *cylinder;* (2) the *piston*; (3) the *connecting rod;* (4) the *crankshaft;* (5) the *inlet valve;* (6) the *exhaust valve;* (7) the *timing gears;* (8) the *camshaft;* (9)

the *lubricating system;* (10) the *carburetor;* (11) the *ignition system;* (12) the *cooling system,* and, finally, (13) a *crankcase,* which is cast integral with (14) the *base.*

The Cylinder, Piston, Connecting Rod and Crankshaft.— The *cylinder,* which is shown at *A* in *Fig. 14,* is an iron block with the inside bored out to a true hole and to an exact size. One end is closed and the other, which is open, is bolted to the crankcase *I* to keep the dirt out and the oil in. The *inlet* and *exhaust* valves *G* and *H* are fitted in the closed end of the cylinder.

The *piston,* see *B,* is a hollow cylindrical casting closed at one end, with grooves cut around it so that iron *piston rings* can be fitted into them. These rings make the piston fit close in the cylinder and yet permit it to slide to and fro easily.

The small end of the *connecting* rod *C* is coupled to it by means of a *wrist pin,* while the other and larger end of the connecting rod is coupled to the *crankpin* of the *crankshaft* which is shown at *D;* and, finally, the crankshaft is mounted in either *babbit* or *bronze bearings.*

The Inlet and Exhaust Valves, The Timing Gears and the Camshaft.— To the crankshaft is *keyed,* that *is,* fixed, a small *timing gear* and this meshes with a larger timing gear, see *E,* that is keyed to the camshaft *F,* and the cams on the latter work the inlet valve *G* and the exhaust valve *H* which seat in the valve openings in the head of the cylinder. They are closed

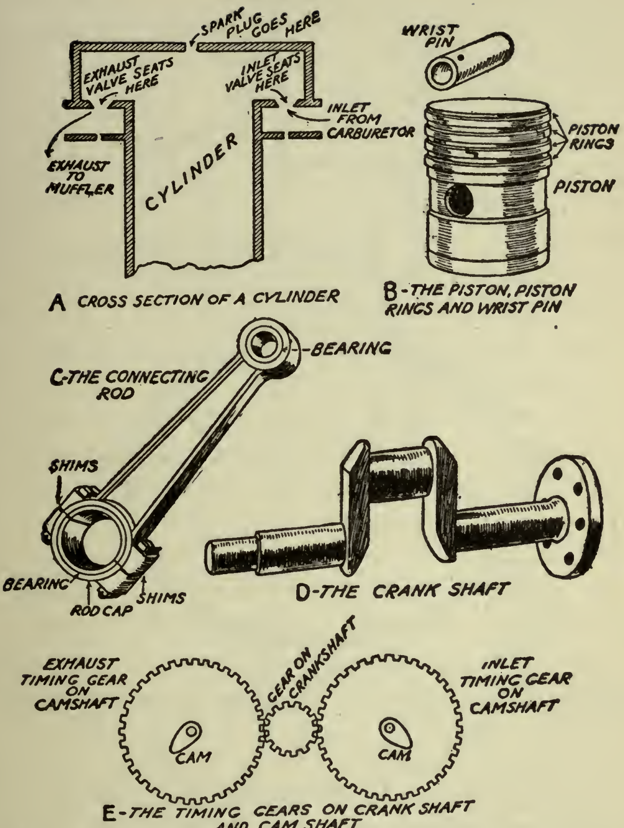
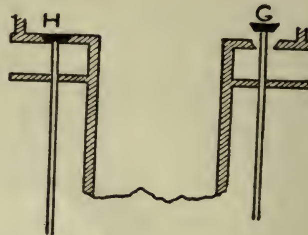


FIG. 14.—THE PARTS OF A ONE-CYLINDER T-HEAD ENGINE

F-THE CAMSHAFT



G & H-THE INLET AND EXHAUST VALVES

I-THE CRANK CASE

FIG. 14 (*Cont.*).—THE PARTS OF A ONE-CYLINDER T-HEAD ENGINE

by spiral springs. The inlet valve opens to admit the *fuel mixture,* and the exhaust valve opens to let out the *burnt gases.*

The fuel mixture is produced by a *carburetor* which mixes the gasoline, kerosene or other *fuel oil,* with the right amount of air to make an explosive mixture

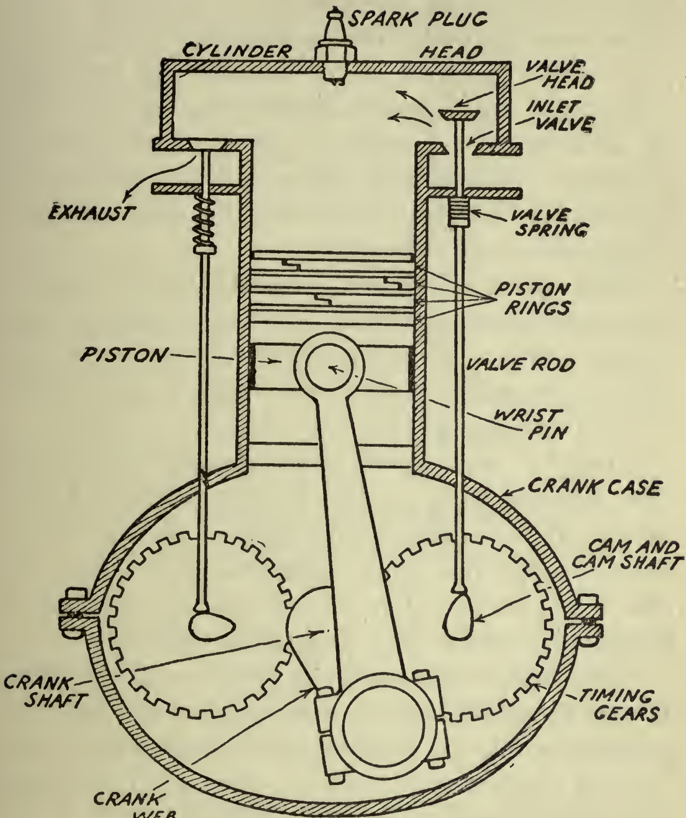


Fig. 15.— Cross Section of a Single Cylinder T-Head Engine
(Shows Intake Stroke)

of it. The carburetor is connected to the inlet pipe which leads into the head of the cylinder and it will be pictured and described in due time. The *spark-plug* sets in the head of the cylinder and the spark is produced at the precise instant it is needed to fire the *fuel charge*[1] by means of either a *battery* or by a *magneto;* these *ignition devices* will also be pictured and described further on, as will be the *lubrication* and *cooling systems* of the engine.

How a Single Cylinder Engine Works.— Knowing now what the parts are of a simple internal combustion engine you can gather from *Fig. 15* the way they are assembled and the next thing to learn about is how the engine works.

First, you must get it clearly fixed in your mind that, different from a steam engine, there is only one *power stroke* in every four strokes of the piston of a tractor engine, that is, the explosive force of the fuel charge acts on the piston only once in four strokes and, hence, it is called a *four stroke cycle engine.*

The Four Strokes of the Engine.— These four strokes are called (1) the *suction stroke;* (2) the *compression stroke;* (3) the *power,* or *explosion stroke* and (4) the *exhaust stroke,* all of which are represented diagrammatically in *Fig. 16.*

The Suction Stroke.— In this stroke the fuel mixture is sucked into the cylinder by the piston as it moves down; in order for it to do so, of course, the

[1] After the *fuel mixture* is compressed in the cylinder it is called the *fuel charge.*

inlet valve must be open and this is done by the timing gears turning the camshaft round so that the high edge of the cam moves up and pushes the valve open. It is shown at *A*.

The Compression Stroke.— When the piston begins to move up on its compression stroke the cam on the camshaft has turned to a point where it releases its pressure on the inlet *valve rod* and the spiral spring

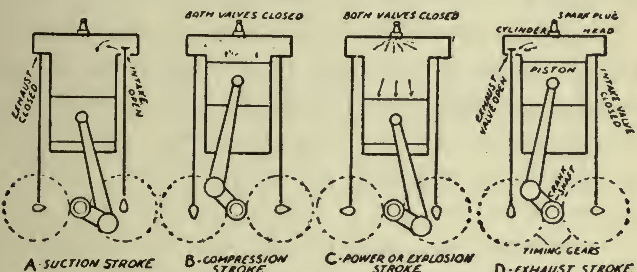


FIG. 16.— DIAGRAM OF THE FOUR STROKES OF A SINGLE CYLINDER ENGINE

on it closes the valve. As both the inlet and the exhaust valve are closed the piston compresses the fuel mixture more and more until it reaches the end of its up-stroke when an explosive fuel charge results. See *B*.

The Power Stroke.— It is at this point that the *timer* of the ignition system, which is also worked by the camshaft, closes the electric circuit and this makes a *jump-spark* take place between the points, or *electrodes* as they are called, of the spark-plug. When the spark jumps between the electrodes it fires the fuel charge and the expanding force of the burning gases drives the piston down and this gives the *power* stroke as pictured at *C*.

The Exhaust Stroke.— At the end of the power stroke the exhaust valve is opened by the cam, on the camshaft, and as the piston moves up on its exhaust stroke it pushes the burnt gases out of the exhaust pipe into the air as shown at *D*. This completes the cycle of strokes when they are repeated all over again.

How the Inlet and Exhaust Valves are Timed.— I think I made it clear above how the cams on the camshaft open the inlet and exhaust valves at the precise moment necessary and how they are closed by the spiral springs when they have performed their respective functions.

From what was said it must also be obvious that for every complete cycle, that is four successive strokes of the piston, the crankshaft makes *two* complete revolutions while the camshaft makes only one revolution. To get this result the gear on the camshaft has twice the number of teeth on it that the gear on the crankshaft has, or to put it another way, the camshaft gear and the crankshaft gear have a *ratio* of 2 to 1, so that the former turns only half as fast as the latter, when, of course, the valves are lifted only once in every two revolutions of the crankshaft.

How Multicylinder Engines Work.— When two or more cylinders are used in an engine and their pistons are connected to the same crankshaft it is called a *multicylinder engine*. Multicylinders are used for tractor engines to (1) reduce the size of it in proportion to the power produced; (2) to increase the speed, and (3) to make the engine run smoother.

As I stated under the last heading a *single* cylinder engine delivers 1 power stroke to every 2 revolutions of the crankshaft. Now with a *two* cylinder engine there is a power stroke to each revolution of the crankshaft, while with a *four* cylinder engine there is a

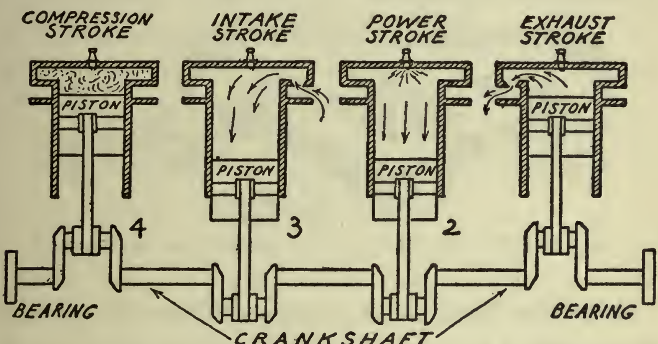


FIG 17.— DIAGRAM OF A FOUR-CYLINDER ENGINE SHOWING HOW PISTONS ARE CONNECTED TO A SINGLE CRANKSHAFT

power stroke to every *half* revolution of the crankshaft when the power developed is practically continuous like that of a steam engine. *Fig. 17* shows how the pistons of a four cylinder engine are connected to a single crankshaft.

With a *six* cylinder engine there is a power stroke to every *one-third* revolution of the crankshaft, when the power strokes overlap each other and, hence, there is no break in the continuity of the turning force, or *torque,* as the engineers call it, and, finally, with an *eight* cylinder engine there is a power stroke to every *one-fourth* revolution of the crankshaft.

The Manifold and What it is For.— Where an engine has two or more cylinders the carburetor is connected with the inlet valve openings and the exhaust valve ports lead to the open air through branched pipes called a *manifold.* It is shown in *Fig. 18.*

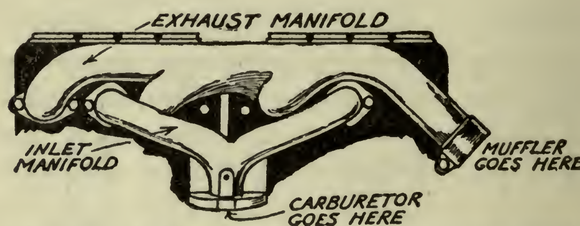


FIG. 18.— THE MANIFOLDS OF A FOUR-CYLINDER ENGINE

How the Muffler is Made.— When the exhaust gases from a cylinder discharge directly into the air they make a report which sounds like that of a pistol. This is caused by the burnt gases which are under a high pressure coming in contact with the free air which is under a lower pressure. To get rid of this noise a silencer, called a *muffler,* is used on some tractors.

There are numerous makes of mufflers on the market, but all of them work on the principle of making the exhaust gases flow forth and back through a number of tubes or around a spiral which reduces the pressure to that of the outside air when they are discharged into it.

How the Engine is Lubricated.— *Kinds of Systems.*— In all engine lubricating systems of whatever kind the oil is contained in the lower part of the crankcase, or a *sump* under it, or is fed into it from a supply tank. From the crankcase, or sump, it is either (1) *splashed* into the cylinders and on the bearings, (2) *splashed* into the cylinders and also carried up to an oil pipe through which it flows or is *circulated* to the bearings, or (3) *forced* by a pump from the sump up to the oil pipe through which it flows to the bearings when it is thrown by the connecting rods into the cylinders, or (4) each bearing is oiled separately by a little pump of its own called an *individual pump,* which pumps the oil from a tank to the bearing that is to be lubricated.

The Splash System.— In this system the crankcase is filled with oil until it is high enough to cover the dippers on the ends of the connecting rods when they are on the lower dead level, or *splash level,* as it is called. As the dippers strike the oil they splash it up into the cylinders and onto the bearings. It is an exceedingly simple lubricating system and a very good one as well. It is shown at *A* in *Fig. 19.*

The Circulating System.— This is really a combined *splash* and *circulating* system. The crankcase has a *sump,* or reservoir, under it and this is nearly filled with oil. The flywheel, which is inclosed in the crankcase, carries the oil up to and into the oil pipe where it runs down into troughs that are cut in the floor of the crankcase; in this way they are kept full, the excess running back into the sump. The connecting rod dippers splash the oil into the cylinders and

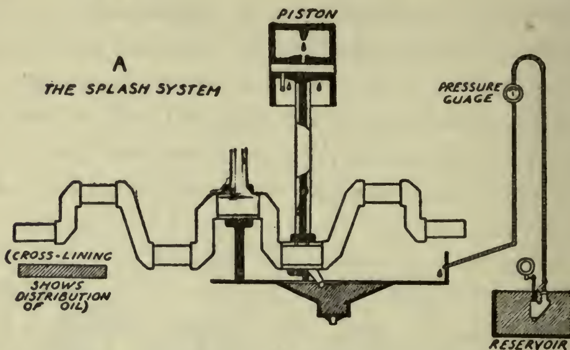


FIG. 19A.—KINDS OF LUBRICATING SYSTEMS

onto the bearings as in the splash system just described. It is shown at *B*.

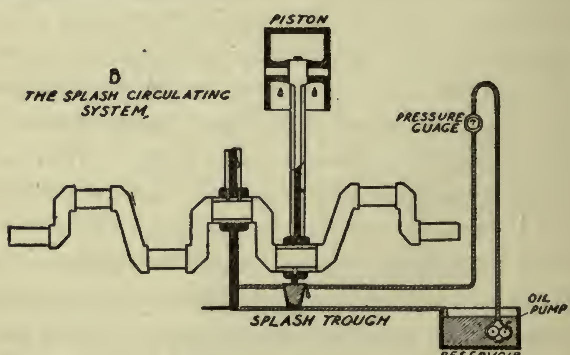


FIG. 19B.—KINDS OF LUBRICATING SYSTEMS

The Force Feed System.—In this system the oil is pumped up from the sump, by an oil pump when it is delivered by the oil pipe to the bearings of the crankshaft, thence on through a hole, or duct, in it and the *crankwebs* to the *crankpins* on which are coupled the connecting rods. The excess oil that drops off of the crankpins is thrown by the ends of the connecting rods into the cylinders and this lubricates the pistons and the wristpins. This is the next best lubricating system that has yet been devised and it is shown at *C.*

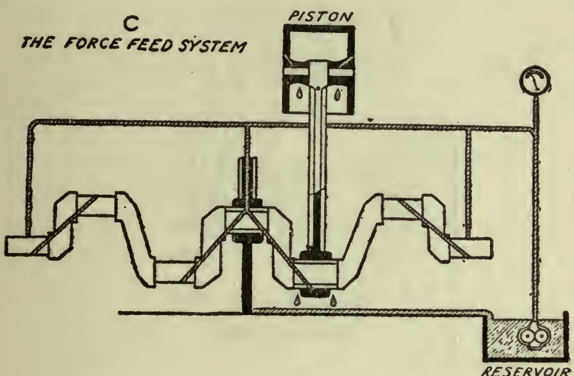
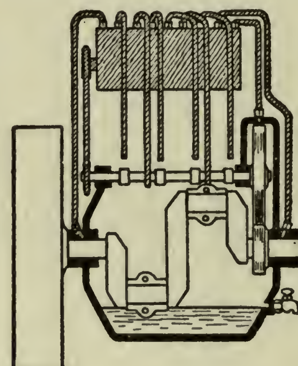


FIG. 19C.— KINDS OF LUBRICATING SYSTEMS

The Individual Pump, Positive Feed System.— This system of lubrication gives added life to the bearings because it supplies fresh oil to them all of the time, whereas the other systems use the same oil over and over again.

The apparatus consists of a steel tank that contains the oil and in the tank are as many small pumps, or *individual pumps* as they are called, as there are bearings to be oiled. The pumps are driven by a ratchet wheel which is rotated by a pawl connected to an eccentric on the camshaft.

A *sight feed* measuring device shows the amount of oil that is being used while a *measuring plunger* permits the amount of oil that flows through the sight feed to be varied at will. The oil that passes through the sight feed then flows to the pump where it is forced to the bearing to be lubricated.



D·INDIVIDUAL PUMP POSITIVE SYSTEM
FIG. 19D.— KINDS OF LUBRICATING SYSTEMS

Kinds of Oil Pumps.— There are three kinds of oil pumps used on tractor engines and these are (1) the *gear pump,* (2) the *plunger pump* and (3) the *individual pump.*

The Gear Pump.— In this pump which is shown at *A* in *Fig. 20,* the oil is carried up by the teeth of the gears. It is a very efficient type of pump and cannot be excelled for positive action.

The Plunger Pump.— This type is a *piston pump* made like those for pumping water. It is worked by an eccentric connected on the camshaft of the engine, and as shown at *B*.

The Individual Positive Feed Pump.— There are two kinds of individual pumps used for positive feed

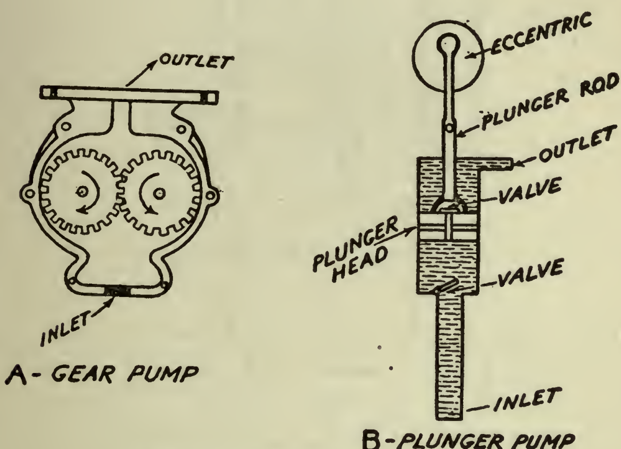


FIG. 20A, B.— KINDS OF OIL PUMPS

lubricators and these are (1) those that have valves, and (2) those that are valveless.

The disadvantage of valve pumps is that foreign matter is apt to settle on the valve seat when the pump will not deliver the oil. Valveless pumps are largely used for tractor lubrication as the lubrication is positive in even the coldest weather. A Madison-Kipp individual valveless pump is shown at *C*.

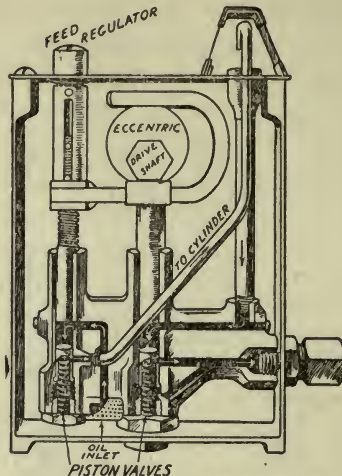


FIG. 20C.— KINDS OF OIL PUMPS

How the Engine is Cooled.— There are two fundamental schemes used for cooling the cylinders of tractor engines and these are by (1) the *air circulating system* and (2) the *liquid circulating system,* and, then, (3) *cooling fans* are also used in combination with both systems.

Air Cooled Engines.— Where the engine is cooled by air the cylinders have radial ribs on them as shown at *A,* in *Fig. 21,* and around these sets a jacket. The air is made to flow from the top of the cylinders, over them between the radial ribs and out through the bottom by means of either (a) a *suction fan* fitted to the fly wheel; (b) the *suction of the exhaust* from the engine, or (c) by a *centrifugal blower.*

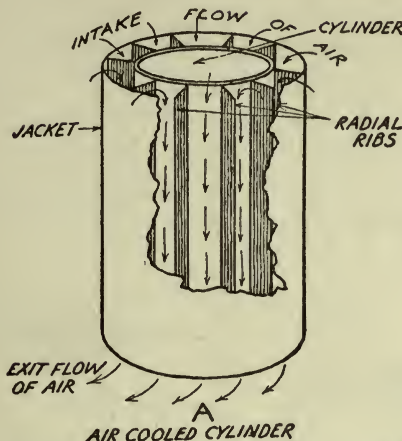


FIG. 21A.—KINDS OF COOLING SYSTEMS

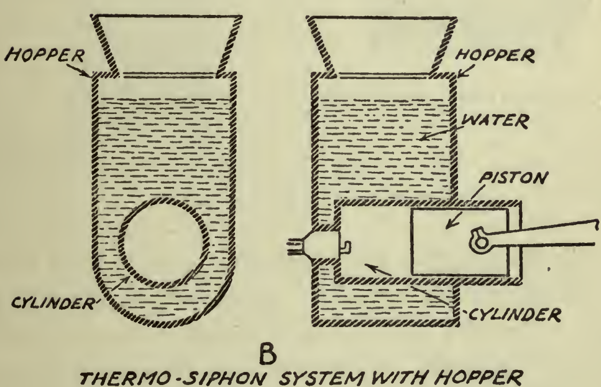


FIG. 21B.—KINDS OF COOLING SYSTEMS

Water and Oil Cooled Engines.— Whether *water* or *oil* is used as the liquid for cooling the engine the cylinders are *jacketed,* and the circulating channel thus formed is connected to either (a) a *hopper,* which is simply a big steel tank that holds the water or oil, or to (b) a radiator which cools the liquid after it is heated by contact with the cylinders. A hopper cooled cylinder is shown at *B* in *Fig. 21.*

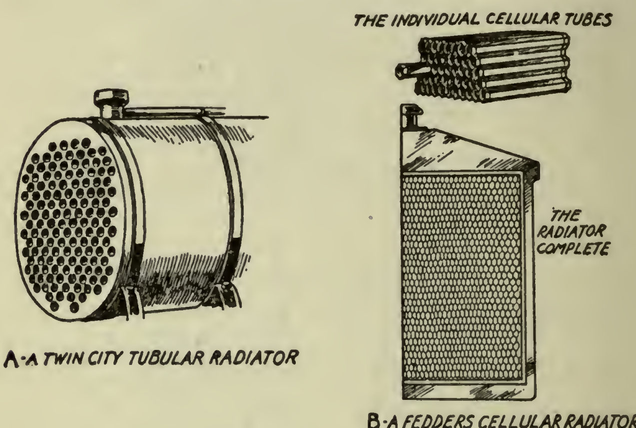


Fig. 22.— Kinds of Radiators

The Radiator.— Radiators are specially built to cool the water or oil rapidly. There are two kinds and these are (1) the *tubular radiator,* and (2) the *cellular radiator.* In the tubular radiator the water or oil circulates *between* a large number of short pipes *through* which the air passes as shown at *A* in *Fig. 22,* while in the cellular radiator, see *B,* the water, or oil flows *through* the tubes and the air blows *between* them.

Kinds of Liquid Cooling Schemes.— There are two ways by which the water or oil is made to circulate around the cylinders and through the radiator and these are (1) by the *thermo-siphon* system and (2) by the *pump circulating* system.

The Thermo-Siphon System.— This is the simplest

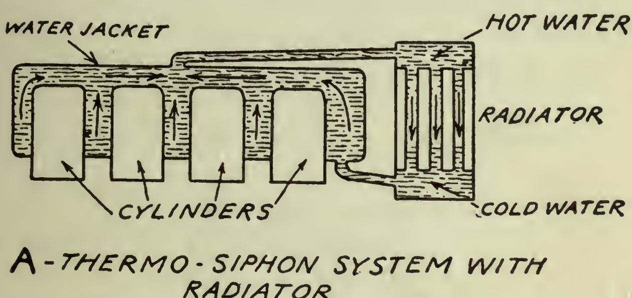


FIG. 23A.— KINDS OF LIQUID COOLING SYSTEMS

scheme for cooling the engine by means of a liquid. The hopper, or radiator, is connected to the jacketed cylinders at the top and bottom and the interior space of both is filled with water or oil.

The principle on which the thermo-siphon system works is this: when a liquid gets hot it becomes lighter and rises to the surface, and conversely the cold liquid drops to the bottom of the vessel by virtue of its being heavier. Hence, when the liquid around the cylinder becomes sufficiently heated it rises to the top and passes into the radiator where it is cooled; it then drops down and flows into the jacketed cylinders where it absorbs the heat and rises again. The scheme is shown at *A* in *Fig. 23*.

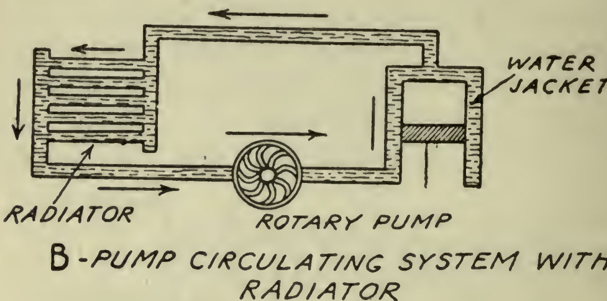


FIG. 23B.—KINDS OF LIQUID COOLING SYSTEMS

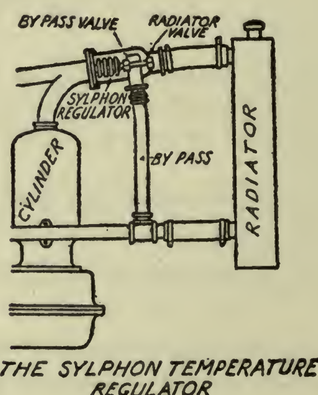


FIG. 23C.—KINDS OF LIQUID COOLING SYSTEMS

The Pump Circulating System.—In this system the radiator is connected with the jacketed cylinders in exactly the same fashion as they are in the thermo-siphon system, but there is coupled in the lower pipe a pump to keep the liquid in circulation regardless of its temperature. See *B*.

The *syphon regulator* is a device that shuts off the circulation of the water until a temperature of 160 to 180 degrees is attained and this is quite necessary when burning kerosene. This regulator is automatic in its

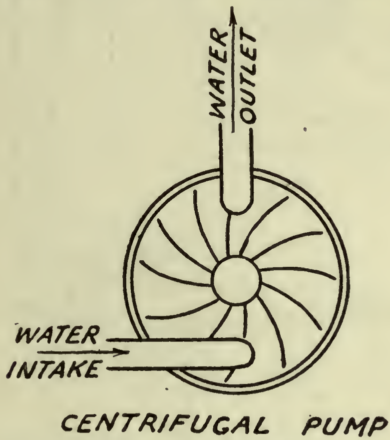


FIG. 24.—KINDS OF ENGINE PUMPS

operation and prevents such kerosene which may be unburned from getting into the crank case.

Kinds of Circulating Pumps.— There are three kinds of pumps used in the pump circulating system, and these are, (1) the *rotary pump;* (2) the *centrifugal pump,* and (3) the *plunger pump.*

The first two pumps named above have rotating elements and these are turned by the pump-shaft which is geared to the crankshaft. The rotary pump is a gear pump and is made like the oil gear pump shown at *A* in *Fig. 20.* The centrifugal pump has an *impeller* and is shown in *Fig. 24,* while the plunger pump

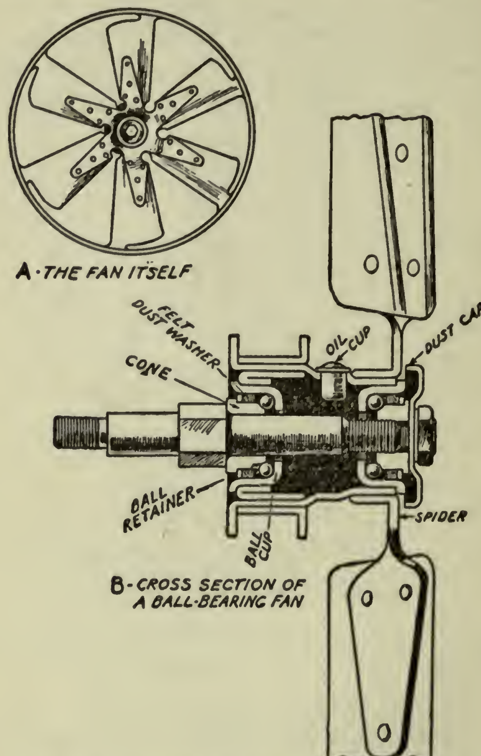
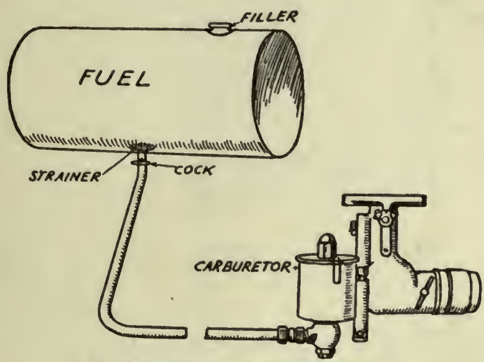


Fig. 25.—The Radiator Cooling Fan

is made like the plunger pump shown at *B* in *Fig. 20.*

The Radiator Cooling Fan.—Where a radiator system is used a fan of the *radial type* is needed to pull the air from the outside through the radiator in order to cool the liquid therein faster. The fan is installed back of the radiator and is driven by the crankshaft through either (1) a *belt;* (2) a *chain,* or (3) by *gears.* With a belt driven fan there is liable to be some slippage though the extent of it is largely a matter of the kind and width of the belt. A radiator fan is shown in *Fig. 25.*



A.-GRAVITY FUEL FEED SYSTEM

FIG. 26A.— FUEL FEED SYSTEMS

How the Engine is Fed with Fuel.— To complete the engine two other auxiliary, but very necessary, devices must be attached to it and these are (*A*) the *fuel system,* and (*B*) the *ignition* system. To supply the engine with fuel there must be (1) a *tank* to contain the gasoline, kerosene, or other fuel oil, and (2) the *carburetor* which measures out the fuel, forms a spray of it and mixes it with enough air to make an explosive *fuel mixture* which is then drawn into the cylinders.

About the Fuel Feed System.— The purpose of the fuel feed system is to keep the carburetor supplied with liquid fuel from the tank. There are three kinds

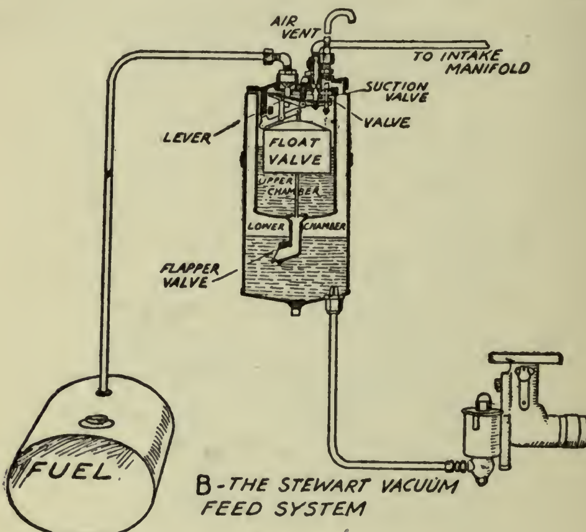


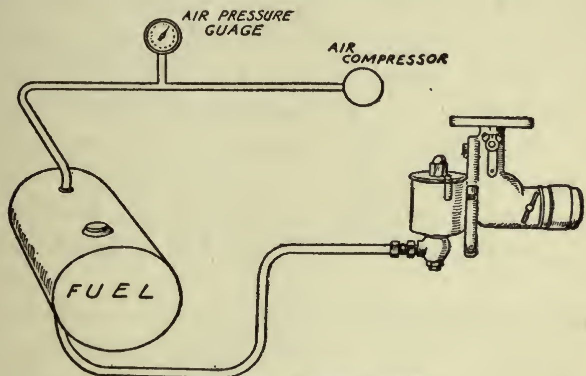
FIG. 26B.— FUEL FEED SYSTEMS

of fuel feed systems used on tractor engines and these are (1) the *gravity feed* system, (2) the *vacuum feed* system and (3) the *air pressure feed* system.

The Gravity System.— This is the simplest kind of a feed, the fuel flowing from the tank into the carburetor by *gravity* since the latter device is below the level of the former as shown at *A* in *Fig. 26*.

The Vacuum System.— The fuel tank in this case can set below the level of the carburetor as shown at *B*. Between the supply tank and the carburetor is a small fuel tank and this is connected with the inlet manifold of the engine.

On the tank there is a float and valve feed which is very like that of a carburetor, to be described further



C - THE AIR PRESSURE FEED SYSTEM

FIG. 26C.— FUEL FEED SYSTEMS

on, and when the intake stroke takes place it pulls the air out of the small feed tank and so forms a vacuum. The pressure of the air on the fuel in the supply tank then pushes it into the vacuum tank. When the latter has a pint or so of fuel in it the suction valve is automatically closed by the float and valve and no more can be drawn in until it is used up.

The vacuum tank is connected with the carburetor and the fuel flows from the former into the latter by gravity as in the gravity system.

The Air Pressure System.— Likewise in the air pressure system the gasoline tank can set lower than the carburetor, a small rotary air pump, or *compressor,* as it is called, driven by the camshaft of the engine, is installed at one end of a pipe that leads to the supply tank and this compresses the air in the latter until from 1 to 4 pounds pressure is had when the liquid fuel is forced through the feed pipe and into the carburetor. A hand operated air pump must be used when there is no pressure in the supply tank and the power pressure pump is not working. A compressed air gauge in the air-pipe line shows the pressure of the air in the tank. The system is shown at *C.*

What the Carburetor is For.— The carburetor is a device that is used to break up the liquid fuel into fine particles and to mix the latter with air in the right proportion to form an explosive fuel mixture.

This is done by forcing the fuel oil from a nozzle into a stream of air which makes a spray of it as shown at *A* in *Fig. 27.* The constriction in the intake air tube at the point where the fuel oil *jet,* that is where the fuel oil leaves the nozzle is called, gives the air a higher pressure, and hence velocity, and this is known as a *Venturi* tube.

How the Carburetor is Made.— To keep the fuel oil from flowing all of the time into the carburetor and to gauge the amount that shall be used by the engine, a *float valve* is employed which automatically opens and closes the pipe that leads to the supply tank.

A carburetor consists of three chief parts and these are (1) a *float chamber;* (2) a *float,* and (3) a *needle valve.* The float is formed of a hollow metal shell whose diameter is about the same as the inside diameter of the float chamber. The needle valve is fixed to

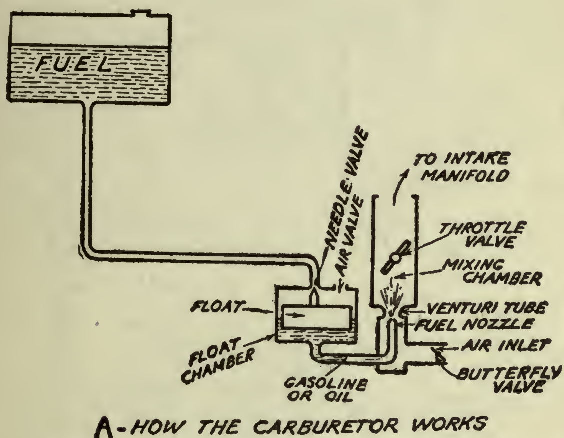
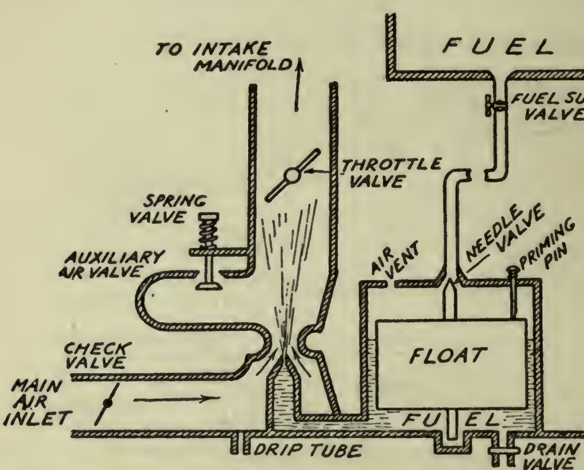


FIG. 27A.— THE PRINCIPLES OF THE CARBURETOR

the top of the float and the latter is then set in the chamber.

How the Carburetor Works.— It must be clear now that when there is no fuel oil in the chamber the float will rest on the bottom of it and the valve will remain open. The fuel oil from the supply tank can now flow into it and as it does so the float rises until it closes the valve when the supply is shut off.

As the engine draws in the fuel mixture the level of the fuel falls on the suction stroke and, of course, the float with it which opens the valve and lets more fuel run into the chamber. In this way the right amount is at all times supplied to the nozzle and this is determined by the *throttle lever* which controls the

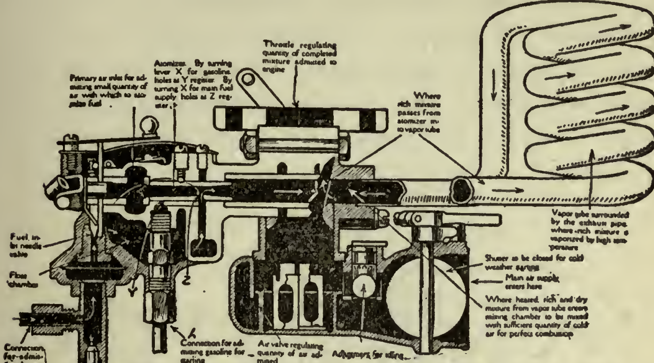


B-CROSS SECTION OF A COMPLETE CARBURETOR

FIG. 27B.—THE PRINCIPLES OF THE CARBURETOR

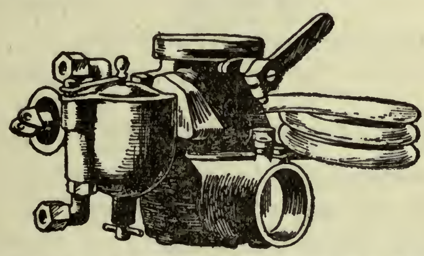
throttle, or *butterfly, valve* in the lower end of the inlet pipe leading to the cylinders.

In tractor engine carburetors, as well as those used on motor cars and motor trucks, there is also an *automatic air valve* which opens into the *mixing chamber* as shown at *B* in *Fig. 27.* This extra air valve supplies more air to the fuel mixture when it needs more air than it is getting from the main air inlet. It is opened by the pressure of the air on the outside of



C-CROSS SECTION OF HOLLEY CARBURETOR WITH VAPORIZER FOR HEAVY OIL FUELS

FIG. 27C.—THE CONSTRUCTION OF A CARBURETOR



D·THE HOLLEY CARBURETOR WITH VAPORIZER COMPLETE

FIG. 27C.—THE PRINCIPLES OF THE CARBURETOR

the valve and closed by a spiral spring. In this way a *rich*[1] or a *lean*[1] fuel mixture can be obtained. A

[1] A *rich mixture* is one in which there is very little air mixed with the fuel oil, and a *lean mixture* is one in which there is a large amount of air mixed with the fuel oil.

cross section of a *Holley* carburetor is shown at *C* in *Fig. 27*, and the carburetor complete at *D*.

Vaporizing the Fuel Mixture.— A carburetor will vaporize gasoline sufficiently to form a good fuel mixture before it is taken into the cylinders but kerosene and heavy oils must be further vaporized by a high temperature before they are drawn into the cylinders.

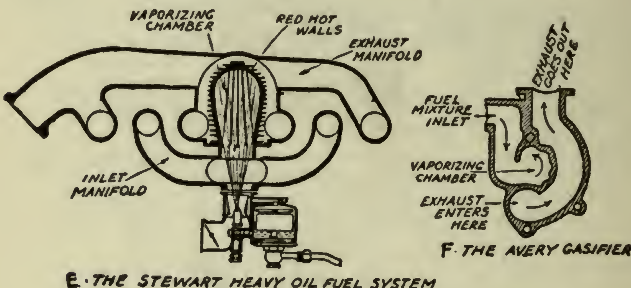


Fig. 27E.— The Principles of the Carburetor

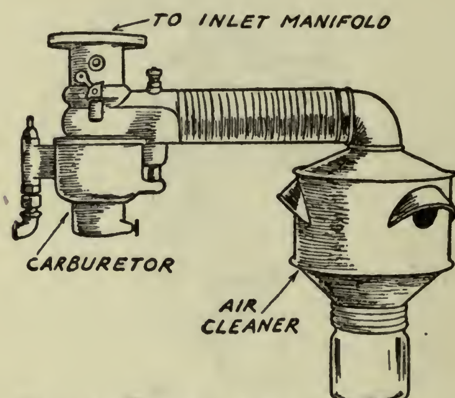
The chief scheme for doing this is to use the heat of the exhaust gases to (1) heat the *air* before it is admitted into the carburetor; (2) to heat the *fuel oil* before it flows into the carburetor; (3) to heat the *mixing chamber* of the carburetor while the fuel mixture is in the process of forming, and (4) to heat the *intake manifold* through which the fuel mixture passes before going into the cylinders. Two of these vaporizing schemes are shown at *E* and *F* in *Fig. 27*.

Kinds of Air Cleaners.— The greatest enemy of the tractor engine is dust and sand which wear out the piston and rings, scores the walls of cylinders and pits the valves. The dust and sand get into the cylinders through the carburetor air intake unless it is fitted with an *air cleaner.* Now there are two kinds of air cleaners and these are (1) *dry air cleaners* and (2) *water air cleaners.*

Fig. 28a.— Kinds of Air Cleaners (How the Dry Air Cleaner Is Made and Works)

The *Bennett* dry air cleaner, see *A* and *B, Fig. 28,* shows how it is made and the way it works is like this: The air is drawn by the suction stroke of the motor through the openings in the sides of the cleaner and into the spiral tubes. These tubes slant downward and give the dust laden air a whirling motion so that the dust is thrown out by centrifugal force when it drops down into the Mason jar while the clean air is drawn up and into the carburetor.

In the *water air* cleaner shown at *C* the dust laden air is drawn by the suction stroke of the engine through the water from the bottom; the dust is absorbed by the water while the cleaned air passes on through it into the carburetor.



B - A BENNETT AIR CLEANER ATTACHED TO THE CARBURETOR

FIG. 28B.—KINDS OF AIR CLEANERS
(The Bennett Dry Air Cleaner Complete)

The Electric Ignition System.— There is only one fundamental scheme used for firing the fuel charges of a tractor engine and this is by *electricity*. There are, however, two kinds of electric apparatus, or *ignition systems* as they are called, employed and these are (1) the *battery system* and (2) the *magneto system*.

What the Battery System Is.— The battery system, or *battery and circuit breaker system,* as it is technically known, consists of (1) a *storage battery,* (2) a *switch,* (3) a *spark coil,* or *ignition coil,* as it is

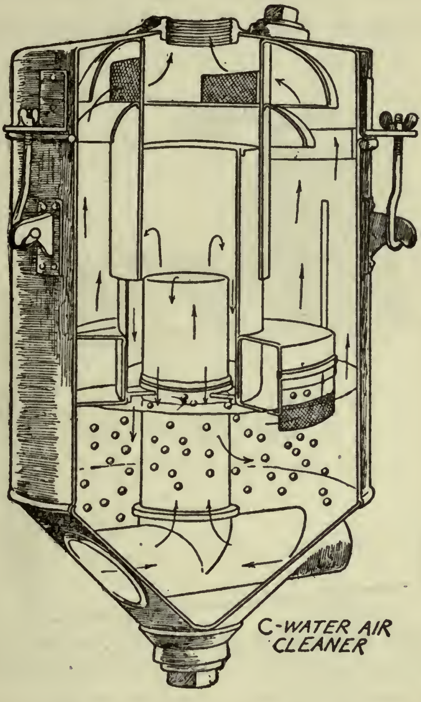
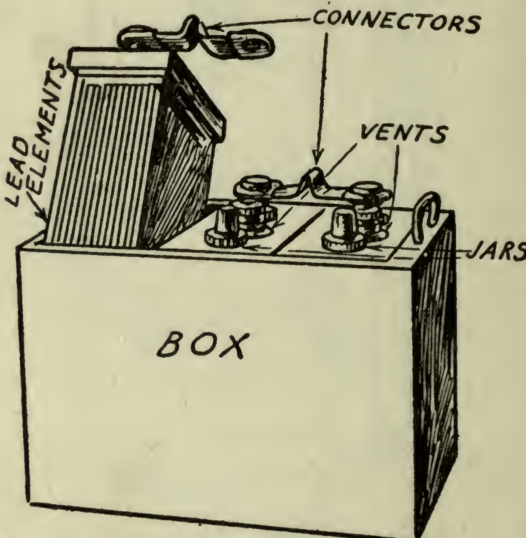


Fig. 28c.—Kinds of Air Cleaners
(How the Water Air Cleaner Is Made and Works)

called, (4) a *circuit breaker,* or *interruptor,* (5) a *distributor* which is also a *timer* and (6) a *spark plug* for each cylinder to be fired.

The Storage Battery.— The storage battery, see *A, Fig. 29,* which is used to supply the electric current, delivers a large constant current until it is exhausted when it must be recharged by a direct current from either (*a*) an *electric generator* driven by the tractor



A-THE STORAGE BATTERY, SHOWING ONE GROUP OF ELEMENTS PARTLY REMOVED

FIG. 29A.— THE BATTERY AND CIRCUIT BREAKER IGNITION SYSTEM

engine, or (*b*) by a current from a *house lighting circuit.* Usually an auxiliary battery of *dry cells* can be switched in so that in case the storage battery runs down you can still operate the ignition system.

The Circuit Breaker and Condenser.— The circuit breaker, or interruptor, shown at *B* is a mechanical device that makes and breaks the battery circuit. It consists of a cam fixed to a shaft driven by the cam-

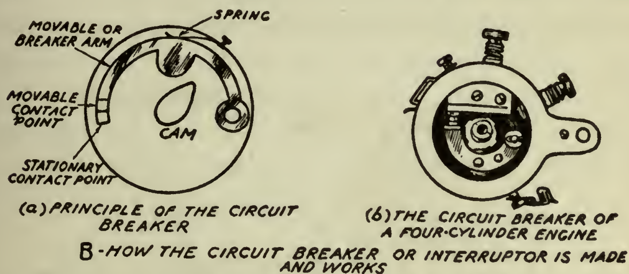


FIG. 29B.— THE BATTERY AND CIRCUIT BREAKER IGNITION SYSTEM

shaft of the engine, and as this rotates it presses a *movable contact point* against a *fixed contact point* and so *makes* the circuit, that is, it closes it. As the corner of the cam slips by the movable contact point the latter

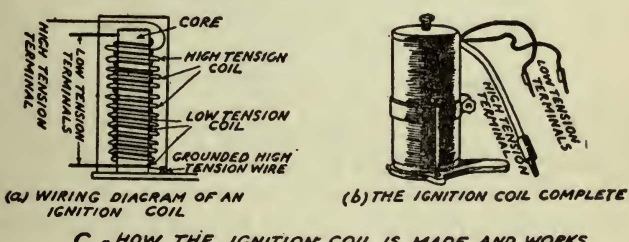


FIG. 29C.— THE BATTERY AND CIRCUIT BREAKER IGNITION SYSTEM

is pulled back by a spring and the current is *broken.* The *condenser* is built up of alternate leaves of tin-foil and waxed paper, and is *shunted* around the contact points to take up the current when they break apart and this prevents it from *arcing* across them.

The Ignition Coil.— The *spark-coil,* or *ignition coil,* see *C,* is built up of a *core* of soft iron around which is wound a couple of layers of thick insulated copper wire and this forms (a) the *primary* or *low tension coil;* around the primary coil, but insulated from it is wound a large number of turns of very fine wire and this forms (b) the *secondary* or *high tension coil.*

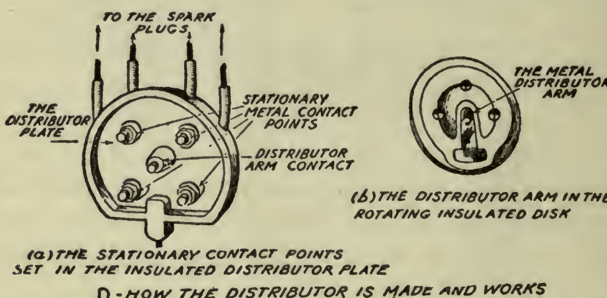
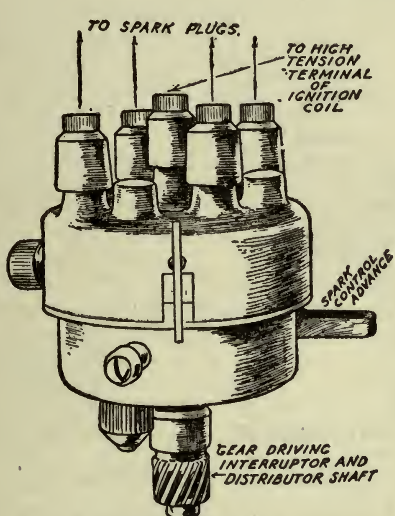


FIG. 29D.— THE BATTERY AND CIRCUIT BREAKER IGNITION SYSTEM

The Distributor.— This device not only *distributes* the *high tension current* that is set up by the ignition coil to the spark-plugs but it *times* the current as well so that it is split up and delivered to each spark-plug at precisely the instant it is needed to fire the fuel charge.

The *timer* or *distributor* is formed of a revolving contact arm fixed to the camshaft which carries the cam of the circuit breaker and hence it rotates with it. Around the contact arm, at equidistant points, are fixed on the *distributor block* as many *stationary contact points* as there are cylinders to be fired and, hence, in passing over these points it makes contact successively with them and so closes the circuit. The distributor is shown at *D,* and the whole ignition head is shown at *E.*



E · THE IGNITION HEAD OF A CIRCUIT BREAKER SYSTEM

FIG. 29E.— THE BATTERY AND CIRCUIT BREAKER IGNITION SYSTEM

The Spark Plugs.— This simple but all important piece of apparatus is formed of a metal *plug body* in which there is placed a *porcelain, steatite* [1] or *mica,* insulator and this is held fast by a metal bushing. Cemented in the insulator is a metal *electrode* with a

[1] Steatite is soapstone.

binding post nut screwed to the top and whose lower end projects beyond the plug body, while the *second electrode* is fixed to the lower end of the plug body. The points of these two electrodes are separated 1/32 of an inch or less and it is across this air-gap that the spark jumps. A spark-plug is shown at *F*.

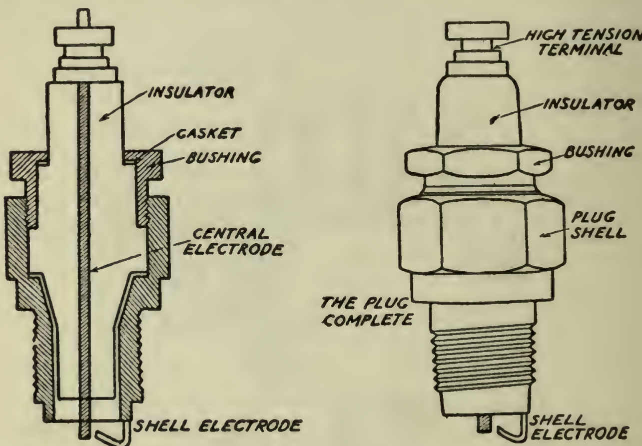


FIG. 29F.— THE BATTERY AND CIRCUIT BREAKER IGNITION SYSTEM

Why the Ignition System is Grounded.— Now, before I describe how the battery and circuit breaker system works you must know how and why it is *grounded.* To *ground* a system means simply that the circuits have only one wire leads, the return circuits being formed by the engine itself. This not only does away with the return wires that would be needed where an all wire circuit is used but it reduces the number of connections and this greatly lessens the possibility of trouble.

How the Battery and Circuit Breaker System Works.— If you will look at the wiring diagram shown in *Fig. 30,* you will get an idea of how the system works. Wherever the wires end that are marked *ground* you will know they are fastened to the

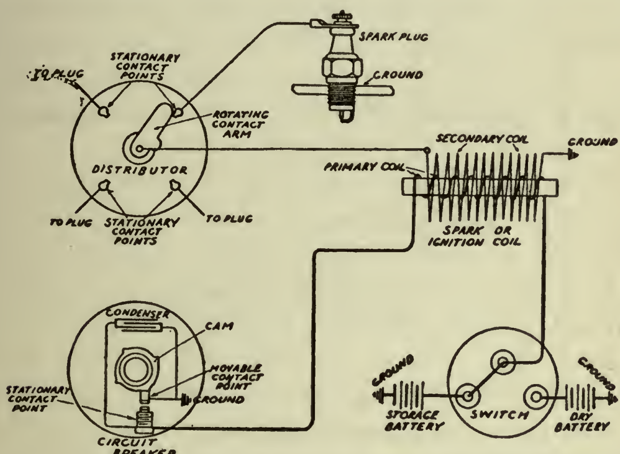


FIG. 30.— WIRING DIAGRAM OF THE BATTERY AND CIRCUIT BREAKER SYSTEM

body of the engine. This is the reason one of the electrodes of the spark-plug is fixed to the plug body.

Let's suppose, now, the engine is running; every time the corner of the cam, which is rotated by the camshaft, strikes the movable contact point of the interruptor, or circuit breaker, it completes the primary circuit, which is shown by the heavy lines, and a large current from the storage battery flows for the instant through the primary coil of the ignition coil.

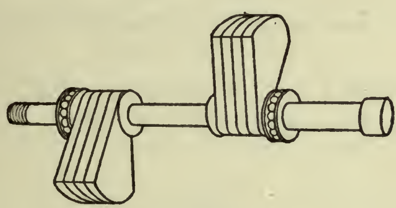
This low-pressure momentary current in the primary coil sets up a high tension current in the secondary coil whose pressure, or *voltage*, as it is called, is high enough to break down an air-gap ⅛ inch long and this makes a good, hot spark. This high tension current flows over to the rotating contact arm of the distributor and as the edge of the arm makes contact successively with the stationary contact points it closes the high tension circuit and a spark takes place at the business end of the spark-plug.

What the Magneto System Is.— Different from the battery and circuit breaker system described above the *magneto ignition system* employs a *magneto,* that is a machine which generates a current like a dynamo and this is run by the pump shaft or cam shaft of the engine. This system includes six distinct parts, namely, (1) a *magneto,* (2) an *interruptor,* (3) a *condenser,* (4) an *ignition coil,* (5) a *distributor,* and (6) the *spark-plugs.*

In all magneto systems the interruptor with its condenser is mounted on the shaft of the rotating element; the ignition coil is either wound separately and mounted in the arch of the inverted U-magnet or else it is wound directly on the rotating element, while the distributor is geared to the armature shaft thus making a single piece of apparatus of the whole system with the exception of the wiring and the spark-plugs.

Kinds of Magnetos.— There are two distinct types of magnetos used for traction engine ignition and these are (1) the *low tension magneto* and (2) the *high tension magneto.* Further, there are two kinds of low tension magnetos, to wit, (*A*) the *inductor magneto,* and (*B*) the *armature magneto,* and the differences in these types and kinds will be described as we go along. In a magneto of whatever type or kind there are two chief parts and these are (a) a *permanent U-magnet,* and (b) a revolving element which rotates between its poles.

The Low Tension Inductor Magneto.— In this kind of magneto two pieces of iron, or *inductors,* as



A - *THE ROTOR*

FIG. 31A.— THE PARTS OF THE REMY INDUCTOR

they are called, are oppositely disposed on a shaft as shown at *A* in *Fig. 31,* and this forms the revolving element, or *rotor,* to give it its right name. This rotor rotates between the poles of the U-magnet, see *B,* and, hence its name.

The ignition coil is built up of a primary coil of thick insulated wire and a secondary coil of fine wire; these coils are mounted side by side as shown at *C,* and are placed on the shaft of the rotor between the iron inductors, or *wings.* One end of the primary

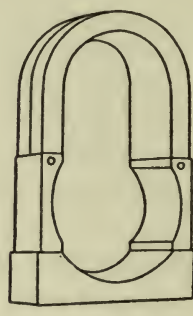


FIG. 31B.—THE PARTS OF THE REMY INDUCTOR

coil is *grounded* to the magnet, which in turn is *grounded* to the engine, and the other end leads to the

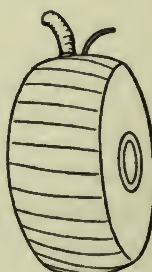


FIG. 31C.—THE PARTS OF THE REMY INDUCTOR

interruptor; one end of the secondary coil is *grounded* and the other end leads to the rotating contact arm of the distributor exactly as in the battery circuit breaker system which I have previously described. An inductor magneto complete is shown at *D*.

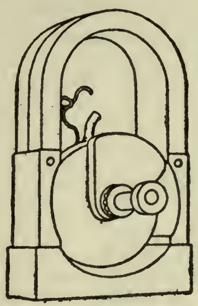


FIG. 31D.—THE PARTS OF THE REMY INDUCTOR

How the Inductor Magneto System Works.— When the rotor revolves in the magnetic field of the permanent steel magnet it causes the magnetic lines of force that flow through the rotor shaft to

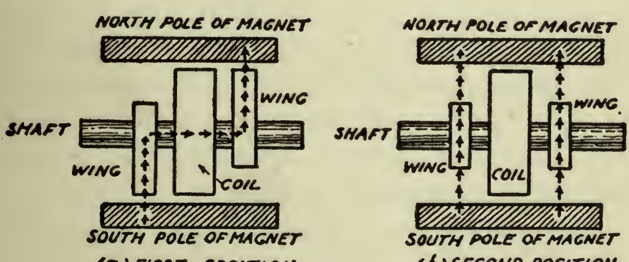


FIG. 31E.—HOW THE REMY INDUCTOR WORKS

change their direction twice every time it makes one complete revolution.

This sets up two electric currents in opposite directions in the primary of the ignition coil and when each current reaches its greatest strength the interruptor suddenly breaks it and this sets up a high tension current in the secondary coil. These reversals of the lines

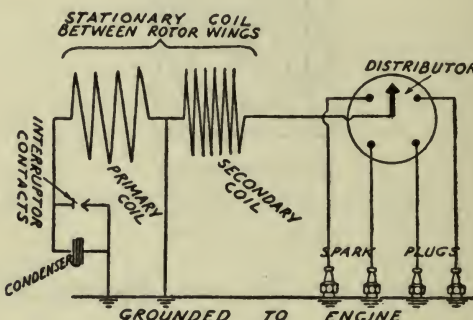


FIG. 32.— WIRING DIAGRAM OF A REMY INDUCTOR MAGNETO IGNITION SYSTEM

of force are shown diagrammatically at *E* in *Fig. 31*. The high tension current is then led to the rotating arm of the distributor which carries it to the spark-plugs of the engine, just as I have described in the battery and circuit breaker system. A wiring diagram of the inductor magneto system is shown in *Fig. 32*.

The Low Tension Armature Magneto.— The rotating element of a low tension armature magneto is made of a *core* formed of a cylindrical piece of iron slotted lengthwise, as shown at *A* in *Fig. 33*, and on this a coil of insulated wire is wound, when an *armature* results.

One end of the wire is *grounded* to the core, and, hence, to the body of the engine, and the other end is connected to a *collector ring* which is mounted on but insulated from the armature shaft. A *carbon*

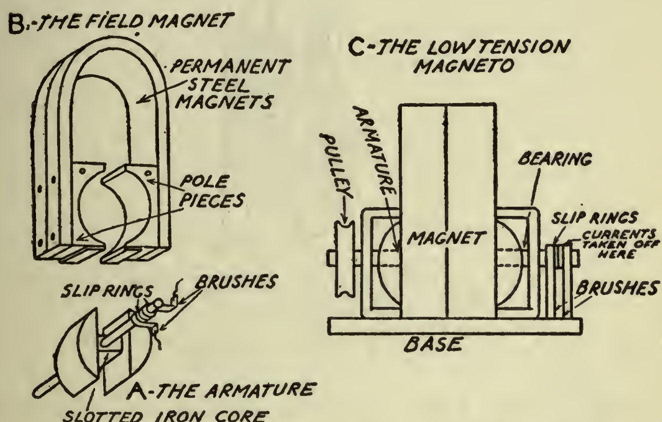
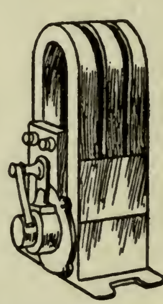


FIG. 33A, B, C.— PARTS OF THE LOW TENSION MAGNETO

brush presses on the ring and takes off the currents as they are set up in the armature coil which rotates between the poles of a permanent U-magnet, see *B*, as in the case of the inductor magneto. The low tension armature magneto is shown schematically at *C*, and complete at *D*.

The carbon brush is connected with the primary coil of an ignition coil and the other end of the ignition coil is *grounded;* one end of the secondary or high tension coil is *grounded* and the other end is connected with the rotating arm of the distributor. The stationary contact points are connected with the spark-plugs just as in the battery and circuit breaker system and in the inductor magneto system.



D-LOW TENSION ARMATURE MAGNETO

FIG. 33D.— LOW TENSION COMPLETE MAGNETO

How the Low Tension Armature Magneto System Works.— When the armature revolves in the magnetic field between the poles of the magnet the wires of the coil cut the magnetic lines of force which flow from the north pole to the south pole and these are changed into electric currents. As the wires on the armature cut the magnetic field twice in every revolution, alternating currents are set up and these are taken off of the collector ring by the carbon brush.

The carbon brush is connected to the interruptor and the latter to one end of the primary coil of the ignition coil, the other end of which is *grounded*. The interruptor, which is rotated by the armature shaft, breaks the circuit when the currents generated in the armature coil reach their greatest intensity and these set up alternating high tension currents in the secondary coil of the ignition coil. One end of the secondary coil is *grounded* and the other end leads to the rotating

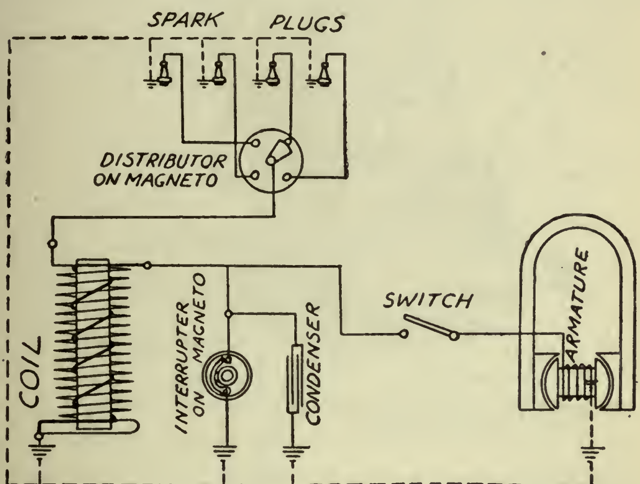


Fig. 34.— Wiring Diagram of a Low Tension Magneto Ignition System

distributor arm, while the stationary contacts of the distributor are connected with the spark-plugs in the cylinders. A wiring diagram of the low tension armature magneto system is shown in *Fig. 34.*

The High Tension Magneto.— In the *high tension magneto* the primary coil of the ignition coil is wound on a slotted armature core. One end of it is grounded and the other leads to the condenser and thence to the interruptor both of which are grounded.

Instead, however, of using a separate coil for the ignition coil the secondary coil is wound directly on the primary coil on the armature so that the latter

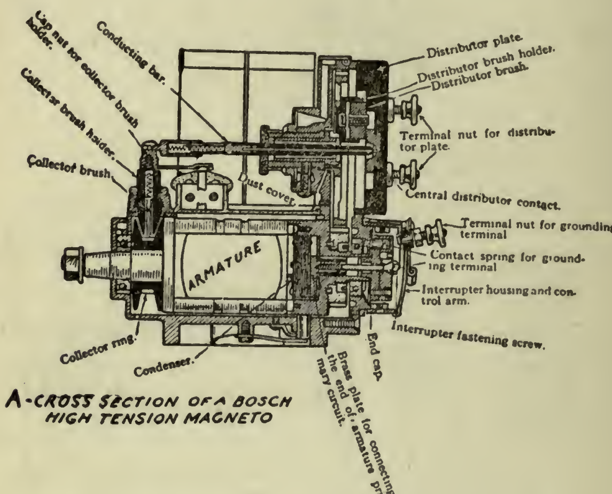


FIG. 35A.—THE HIGH TENSION MAGNETO SYSTEM

is really a revolving induction coil. One end of the secondary coil is grounded to the armature core and the other end leads to the collector ring.

The carbon brush is connected with the rotating arm of the distributor, while the four stationary contact points lead to their respective spark-plugs as in all ignition systems. A cross section view of a high tension magneto is shown at *A*, in *Fig. 35*, and the magneto complete at *B*.

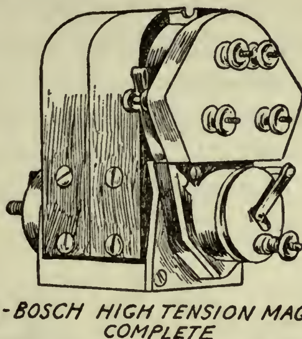


FIG. 35B.—THE HIGH TENSION MAGNETO SYSTEM

How the High Tension Magneto System Works. — When the armature is rotated low tension currents are set up in the turns of wire in the primary

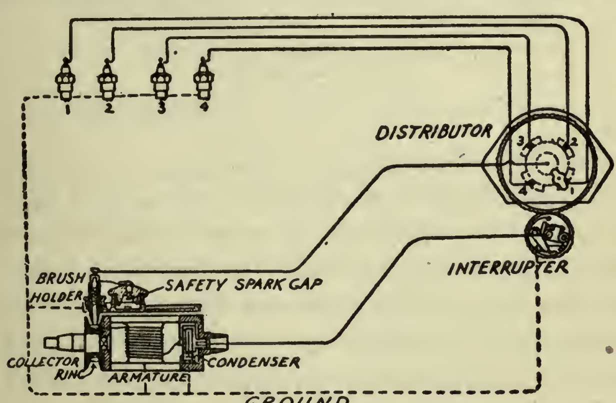


FIG. 36.—WIRING DIAGRAM OF A HIGH TENSION MAGNETO IGNITION SYSTEM

coil as they cut across the magnetic field. As these currents reach their maximum intensity the interruptor breaks the circuit and this sharp break sets up high tension alternating currents in the secondary coil and delivers them to the collector ring. Here they are taken off by the brush whence they flow to the distributor which carries them to the spark plugs. A wiring diagram of a high tension magneto system is shown in *Fig. 36*.

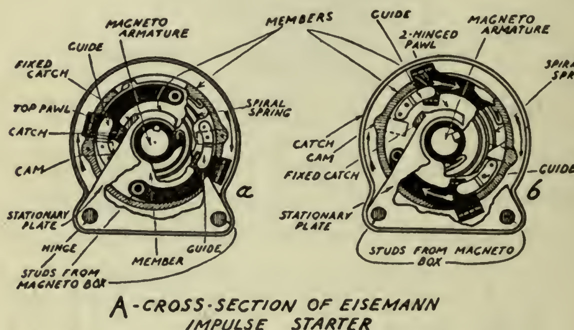


FIG. 37A.— THE EISEMANN IMPULSE STARTER

The Use of the Impulse Starter.— Where a battery and circuit breaker ignition system is used on a tractor, you have the full current strength to start with the moment you close the switch, but not so with the magneto for it will not deliver its full current strength until it is running at its normal speed. This makes it hard to crank a magneto equipped tractor by hand.

To obviate this difficulty an *impulse starter* is attached to the magneto, and, as its name implies, it gives a quick turn to the armature on starting so that it will develop its full current strength at the right instant to give each cylinder in turn a hot spark at the starting speed. An *Eisemann* impulse starter is shown at *A* in *Fig. 37,* and on an *Eisemann* magneto at *B*.

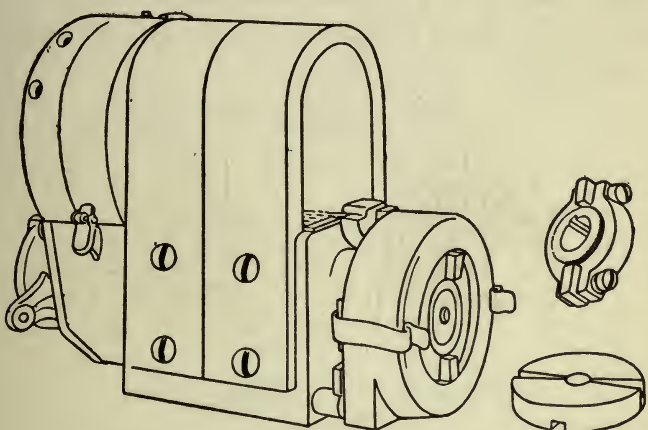


FIG. 37B.— EISEMANN IMPULSE STARTER ON A TRACTOR ENGINE MAGNETO

The Use of the Tractor Engine Starter.— Of over two hundred makes of tractors the engines of all but twenty are cranked by hand, though most of them have magnetos which are fitted with impulse starters. Of the twenty that are fitted with starting devices half of them are operated by electric current and the rest by gas and air.

The Electric Starter.— There are a number of reasons why starters have not found favor thus far with makers and users of tractors. Chief among these is that the magneto, which is fitted with an impulse starter, makes it easy to crank the engine by hand.

The Electric Starter.— The *electric starter* comprises four chief parts, *i. e.,* (1) a *storage battery,* (2) an *electric motor,* (3) a *mechanical drive* and (4) a *switch.* The drive is a device that is coupled to the

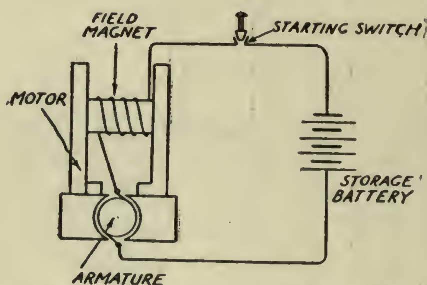
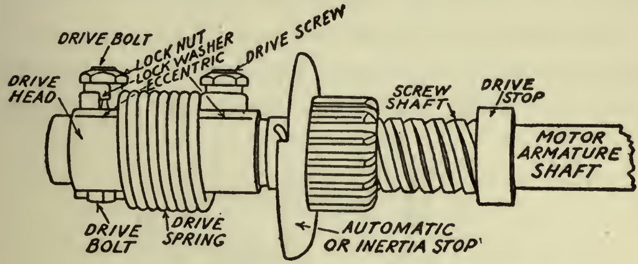


FIG. 38A.— THE ELECTRIC MOTOR STARTER SYSTEM

shaft of the armature of the motor and is connected with the shaft of the engine when it is being started and which is disconnected from the engine automatically after the engine is started.

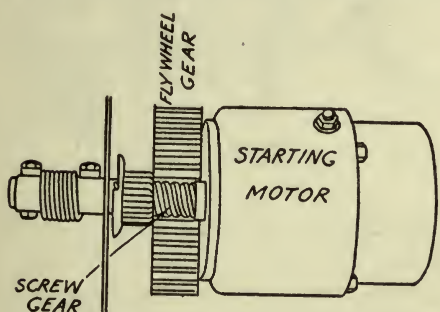
The electric motor, storage battery and switch are connected in *series* as shown at *A* in *Fig. 38.* Now when you want to start the engine you press in on the starting switch and the current from the battery runs the motor. This spins the threaded drive shaft, which is shown in detail at *B,* and then the weighted gear on the screw shaft is screwed into mesh with the gear cut in the rim of the flywheel of the engine when it turns the crankshaft over.

When the engine is running at about its normal



THE BENDIX ELECTRIC STARTER DRIVE

FIG. 38B.—THE ELECTRIC MOTOR STARTER SYSTEM



THE ELECTRIC STARTER COMPLETE

FIG. 38C.—THE ELECTRIC MOTOR STARTER SYSTEM

speed it causes the weighted screw gear to turn faster than the threaded sleeve and this makes it unscrew itself out of mesh. The electric starter complete is shown at *C*.

The Gas and Air Starter.— The principle on which the *Christensen* gas and air starter works is that of charging the engine cylinders with a ready-made fuel mixture and the explosion of the mixture starts the engine.

The starter consists of (1) an air compressor, (2) a compressed air tank, (3) a carburetor, (4) a compressed air gauge, (5) a gas distributor, (6) a clutch

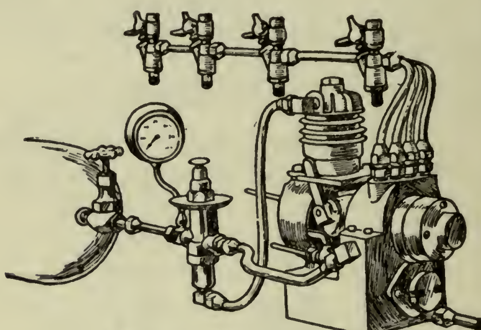


FIG. 39.— THE CHRISTENSEN GAS STARTER

for the air compressor, and (7) a check valve for each engine cylinder.

To start the tractor engine compressed air is released from the tank and this passes through the starting carburetor, together with some gasoline, which is independent of the engine carburetor. The starting carburetor converts the air and gasoline into a highly explosive fuel charge and this is delivered to each cylinder of the engine on its power stroke by the starting distributor. The spark then fires each cylinder successively until the engine is started and begins to run on its own fuel mixture. The Christensen starter is shown in *Fig. 39*.

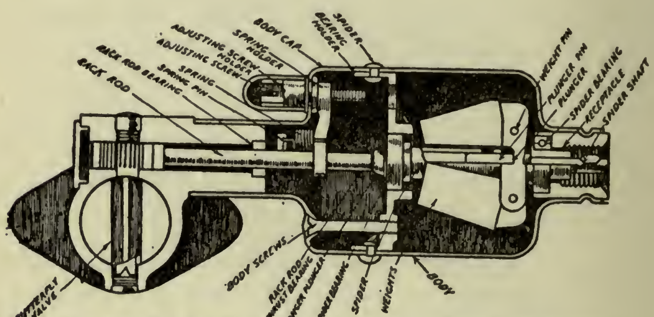
The Use of the Governor.— Nearly every tractor engine is fitted with a *governor* to control its fuel supply so that it will run at practically the same speed from *no load* to *full load* and this is very important, especially where the engine is used for belt work, since the load is always variable. Now there are three kinds of governors used on tractor engines and these are (1) the *centrifugal*, or *flyball* governor, (2) the *floating* governor, and (3) the *electric* governor.

The Centrifugal, or Flyball, Governor.— The principle of this type of governor is the same as that used on a steam engine, that is, a pair of weights which tend to fly apart farther the faster they are rotated, moves a lever that closes the throttle valve accordingly, or as the speed decreases they are forced together by a compression spring and this opens the valve.

The centrifugal governor is mounted between the carburetor and the intake manifold and is connected by means of a flexible shaft to some rotating part of the engine. The throttle valve which is normally in a position so that it does not keep the fuel mixture from flowing into the cylinders is closed by the centrifugal action of the governor just as soon as the engine is running at its normal speed.

The construction of a *Pierce* governor is shown in cross section at *A* in *Fig. 40* which will also give you a good idea of how it works. The governor may be driven from any rotating part of the engine such as the camshaft, magneto shaft or pumpshaft.

The Floating Governor.— The principle of the floating governor is the same as that involved in a ball that rides on a jet of water, that is, the control disk of the governor rides on the column of gas that passes through the governor. The greater the force of the



A-HOW THE CENTRIFUGAL OR FLY BALL GOVERNOR IS MADE AND WORKS

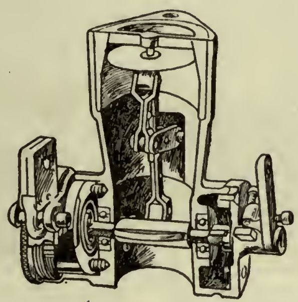
FIG. 40A.— KINDS OF ENGINE GOVERNORS

jet of water the higher the ball will ride and, likewise, the stronger the pressure of the column of gas the higher the governor disk will ride.

This disk which is balanced against the force of a spring opens and closes the butterfly throttling valve between the carburetor and the intake manifold of the engine. A cross section of the *Monarch* floating governor is shown at *B* in *Fig. 40*.

The Electric Governor.— The electric governor of the *Remy Company* consists of two pieces of apparatus built into one unit. Named, these pieces of apparatus are, (1) the *electric generator,* and (2) the *governor lever.*

The generator is a simple direct current dynamo and this develops current for starting, lighting and ignition. The generator is mounted so that it will turn through an arc of 30 degrees. The current that flows through



B - CROSS-SECTION OF THE MONARCH FLOATING GOVERNOR

FIG. 40B.— KINDS OF ENGINE GOVERNORS

the field coils of the generator causes the iron cores of the field magnets to become strong electro-magnets and, in virtue of their magnetic attraction for the armature a *magnetic drag* is set up in the latter; this being the case the armature in rotating in this magnetic field tends to turn the field magnets in the direction that the armature is rotating.

The governor-lever is operated by the turning of the field magnets of the generator and this opens and closes the carburetor throttle instantly when the tractor load is increased or decreased, thus providing an automatic electric governor that accurately controls the speed of the engine. The generator and governor are enclosed in an iron case that is both dust and waterproof. It is shown at *C* in *Fig. 40.*

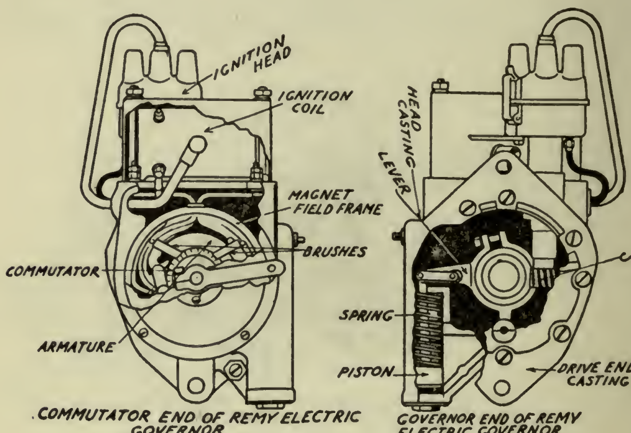


Fig. 40c.— Kinds of Governors

The Power Take Off.— All tractors with one or two exceptions are provided with a *power take off,* that is, the engine can be disconnected from the tractor and its power used for driving stationary machinery.

The pulley which is attached to the engine of the tractor sets on either (*A*) the right-hand side of the tractor or else (*B*) on the front end of it. The pulley is driven by the engine through either (1) a *direct drive,* which means that it is coupled direct to the engine shaft, (2) by *gears,* or (3) by a *friction drive.*

In most of the makes of tractors the pulley is fitted with a *pulley clutch* so that the machine which is being used can be stopped without stopping the engine as well as starting it easier. Likewise some tractors are fitted with a *pulley brake* so that the belt power can be

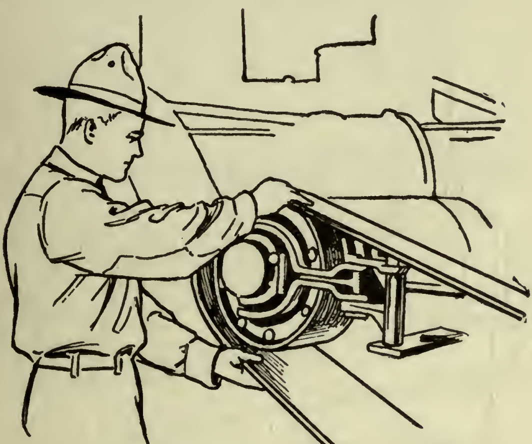


FIG. 41.— THE POWER TAKE-OFF

brought to a stop very quickly after the engine is stopped or the pulley clutch is released.

The widths and diameters of pulleys vary on different sizes and makes of tractors but the *tractor belt speed* that will meet the widest range of conditions is 2600 feet per minute, according to the rating of the *Society of Automotive Engineers.* The pulley of a power take off with its clutch is shown in *Fig. 41.*

The Tractor Engine Complete.— Finally, when all of the above parts and devices are assembled into a single unit you have the tractor engine, complete as shown in *Fig. 42*.

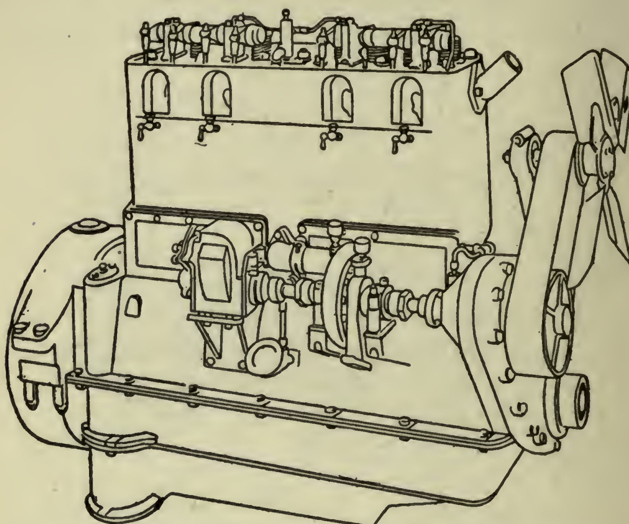


FIG. 42.— INCLOSED FOUR-CYLINDER VALVE-IN-THE-HEAD 40-HORSE POWER STEARNS ENGINE

Finally About Tractor Lighting.— There are two schemes for providing lights on a tractor so that it is available for night work and these are (1) by using *gas*, and (2) by using *electricity*.

Acetylene Gas Lighting.— In this lighting scheme acetylene gas is made in an apparatus called a *generator* which causes water to drop on *calcium carbide*. It is easy to handle and gives a very strong, bright light.

Electric Lighting.— There are three ways by which tractors can use electricity for lighting and these are (1) by a *storage battery* alone; (2) by an *electric generator* alone, and (3) by a combination of the *storage battery* and a *generator.*

Where a storage battery alone is used it must be charged from a lighting circuit and this means more than less bother. An electric generator driven by the tractor engine will give you light and plenty of it but only when the engine is running. Hence the only satisfactory way to light a tractor by electricity is to equip it with a storage battery and a generator just as motor cars are.

When the engine is running the generator delivers a current and this charges the storage battery, and when the engine is stopped the storage battery supplies current to light the lamps.

CHAPTER III

(*Continued*)

THE MECHANISM OF A TRACTOR

PART II

HOW THE TRANSMISSION SYSTEM IS MADE AND WORKS

THE transmission system comprises a number of elements and chief among these are (1) the *transmission clutch,* (2) the *transmission gears,* or *transmission* as it is called for short, (3) the *differential*

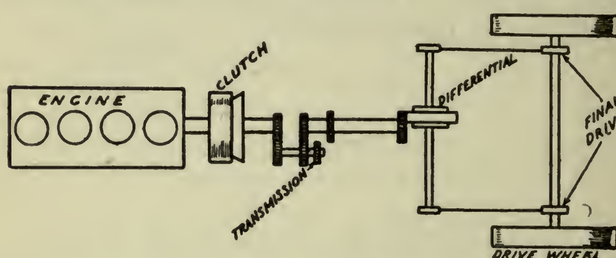


FIG. 43.—DIAGRAM OF THE TRANSMISSION SYSTEM

gears, or just *differential,* and (4) the *final drive.* The transmission clutch, so-called to differentiate it from the pulley clutch, connects the crankshaft of the engine with the transmission gears; the latter are all connected with the differential, where one is used, and, lastly, this connects with the final drive as shown diagrammatically in *Fig. 43*.

What the Transmission Clutch is For.— Since an internal combustion engine develops power only when it is running at its normal speed the engine must be disconnected from the tractor, or other load for that matter, when you start it up. As it gathers momentum and attains its normal speed the tractor can then, and only then, be gently and gradually connected with the crankshaft of the engine, and to do this a *transmission clutch* is needed.

Now the clutch of a tractor is a most peculiar and particular piece of mechanism and, as it has to cushion the power when it picks up the load, it is likewise very important for on its action largely depends the life of the transmission devices back of it as well as that of the engine in front of it. Hence, if it is to give you first class service it must not slip, drag, grab or stutter.

Various Kinds of Clutches.— All clutches used in tractor transmission systems are based on the principle of *friction,* that is, two surfaces, one of which is fixed on the end of the crankshaft and the other on the end of the clutchshaft, are so arranged that they can be brought into contact gradually by the tractioneer and by the friction so produced they will soon rotate together as though they were a single unit.

There are no less than seven different kinds of clutches used on tractors at the present time and these are (1) the *single disk clutch,* (2) the *multiple disk* *clutch,* (3) the *cone clutch,* (4) the *expanding band clutch,* (5) the *expanding shoe clutch,* (6) the *contracting band clutch,* and (7) the *friction wheel clutch,* though the latter device is not in the strict sense a clutch at all though in a few tractors it is used as such.

How Clutches are Made and Work.— In all clutches except the so-called friction wheel clutch, the surfaces are held in contact with each other either by a

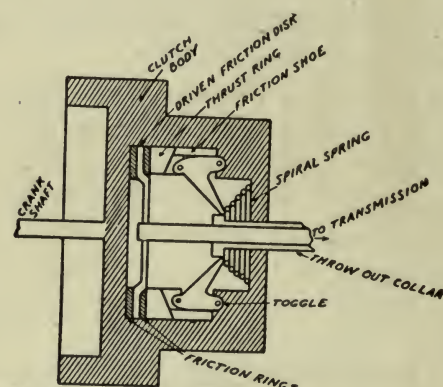


FIG. 44A.— HOW A SINGLE DISK CLUTCH IS MADE AND WORKS

powerful spring or else by a clutch lever and they are only disconnected by either pressing in on a clutch foot pedal or by reversing the clutch bar.

The Single Disk Clutch.— This clutch is also known as a *dry-plate clutch* because formerly the disks, or plates, as the metal surfaces which make contact with each other are called, were immersed in oil. In this clutch a single disk, or plate, is rigidly mounted on the end of the clutchshaft between two asbestos rings which are supported by the flywheel on the crankshaft of the engine.

When there is no pressure exerted by the tractioneer on the clutch pedal, or clutch lever, two or more pivoted

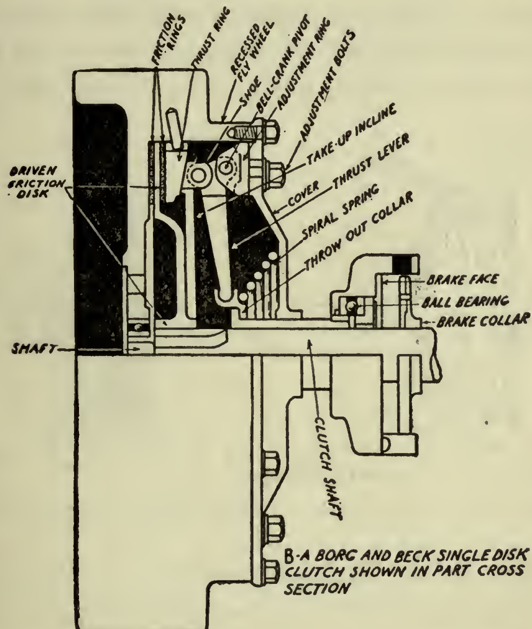


FIG. 44B.— HOW A SINGLE DISK CLUTCH IS MADE AND WORKS

arms or *bell-cranks* act by means of a powerful spiral spring like so many wedges and this forces the disk or plate into contact with the asbestos rings. When you press in on the clutch pedal, or lever, the disk and the rings are pushed apart and this disconnects the engine from the transmission. This clutch is shown in the diagram at *A* in *Fig. 44* and a *Borg* and *Beck* single-plate, dry-disk clutch is shown in partial cross section at *B*.

The Multiple Disk Clutch.— This clutch consists of a number of disks, or plates, fixed to the clutchshaft and an equal number of rings secured to the inside of the rim of the flywheel. These disks and rings

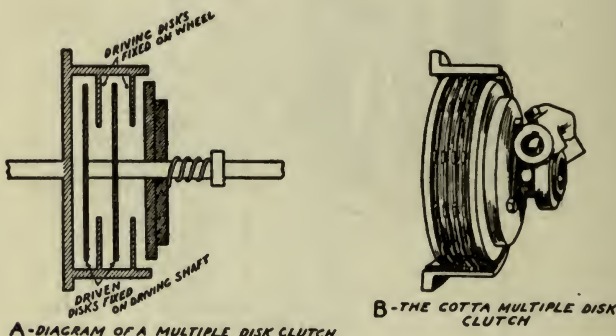


FIG. 45.— HOW A MULTIPLE DISK CLUTCH IS MADE AND WORKS

alternate and interleave as shown at *A* in *Fig. 45*. It works on the same principle as the single disk clutch. A spiral spring keeps the disks on the clutch shaft in firm contact with the rings that are keyed to the flywheel rim, though they can be forced apart by either pressing down on the clutch pedal or throwing the clutch lever. The *Cotta* multiple disk clutch is shown at *B*.

The Cone Clutch. In this type of clutch the flywheel is recessed, that is, hollowed out so that a conical member will fit into it. This member, which is usually of pressed steel and covered with leather, is keyed to the end of the clutchshaft, as shown in the diagram at *A* in *Fig. 46.* Now when the clutch lever is released the spiral spring forces the cone into the flywheel of the engine when, of course, the friction be-

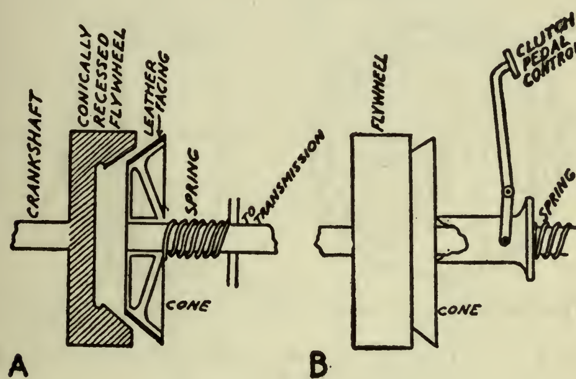


FIG. 46.— HOW THE CONE CLUTCH IS MADE AND WORKS

tween them will make them revolve together as though they were a single piece. *B* shows how the cone clutch is worked by the clutch pedal.

The Expanding Band Clutch.— In this clutch a flexible steel band, whose outside surface is covered with asbestos, is secured to the clutchshaft and sets inside of the recessed flywheel of the engine. The ends of the band are pivoted to the arms of the toggle joint and this in turn is connected by a rod to a clutch lever all of which is shown diagrammatically at *A* in *Fig. 47,* and complete at *B*. This band is kept expanded by a spring when they grip the rim of the flywheel. To disconnect the clutchshaft from the engine you pull a lever and this makes the band contract a little and so relieves the pressure.

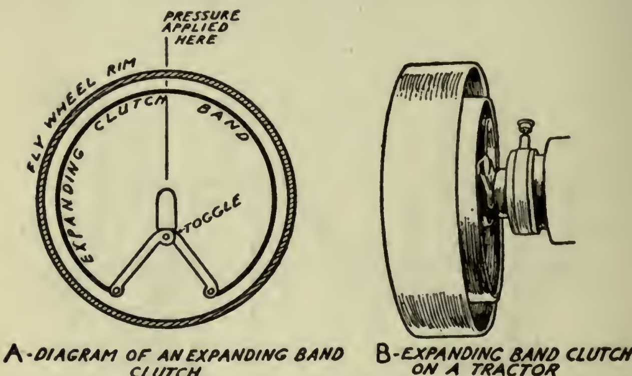
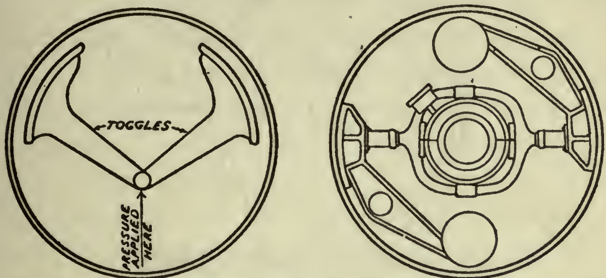


FIG. 47.—HOW THE EXPANDING BAND CLUTCH IS MADE AND WORKS

The Expanding Shoe Clutch.—This clutch works in about the same way as the expanding band clutch, except that a number of wooden blocks, called *shoes,* are secured to the clutchshaft by a toggle-joint or bell-cranks as shown at *A* in *Fig. 48*. These shoes set inside the flywheel of the engine and are made to press out and against the rim by means of a spring. To disconnect the clutch you pull the clutch lever when they move toward the center which reduces the friction and the clutch elements can then rotate separately.

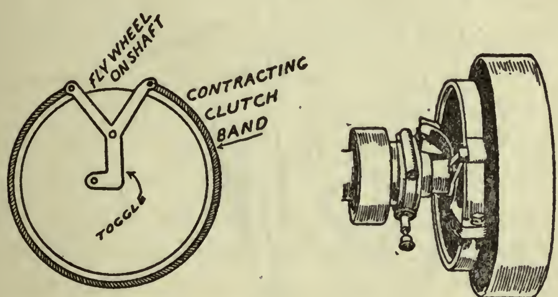
The Contracting Band Clutch.— With a clutch of this type a steel band lined with asbestos is used that is very like the expanding band type described above



A-DIAGRAM OF AN EXPANDING SHOE CLUTCH

B-THE RUMELY EXPANDING SHOE CLUTCH

FIG. 48.— HOW THE EXPANDING SHOE CLUTCH IS MADE AND WORKS

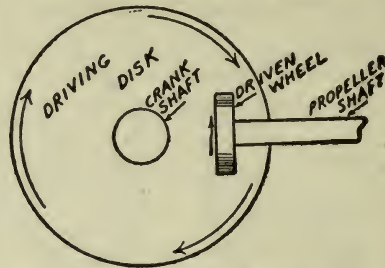


A-DIAGRAM OF A CONTRACTING BAND CLUTCH

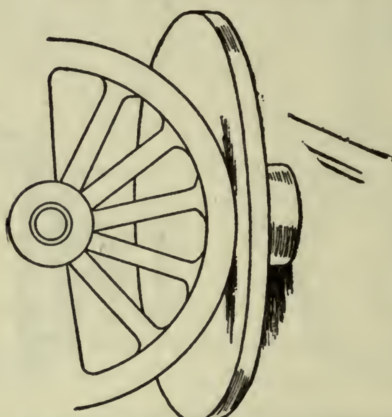
B-THE TWIN CITY CONTRACTING BAND CLUTCH

FIG. 49.— HOW A CONTRACTING BAND CLUTCH IS MADE AND WORKS

but in this case the band fits around the rim of a wheel that is fixed to the flywheel of the engine. The ends of the band are connected with a toggle-joint and when this is pressed in by a spring it draws the band tight on the wheel when the clutchshaft will rotate



A-THE FRICTION DRIVE CLUTCH



B-THE ANDREWS FRICTION DRIVE CLUTCH

Fig. 50.—How the Friction Drive Clutch Is Made and Works

with the crankshaft. It is shown schematically at *A* in *Fig. 49* and the actual clutch on a *Twin City* tractor is shown at *B*.

The Friction Drive Clutch.— This clutch consists of a wheel keyed to the clutchshaft and whose rim is covered with leather. This wheel presses on the smooth flat surface of the flywheel of the engine and at right angles to it when the clutchshaft is made to revolve by the rolling frictional contact between them. Hence it is a friction drive rather than a friction clutch. It is shown in principle at *A* in *Fig. 50,* and as used on the *Andrews* tractor at *B.*

The Transmission.— Since the engine must run at a practically constant speed and the tractor must travel at different speeds there must be some connecting mechanism between them to increase and reduce the speed of the tractor without affecting the speed of the engine and this is done by means of a *transmission, gearset,* or *change-gears* as this part is variously called.

There are two kinds of transmissions used for changing the speed of tractors and these are (1) the *friction transmission,* and (2) the *change-gear transmission.* About 1 per cent. of 1920 tractors are fitted with the first kind and the remaining are equipped with the latter kind.

The Friction Wheel Transmission.— This transmission is constructed exactly like the friction clutch described under the foregoing heading. In fact a friction drive clutch also serves as a transmission since when the clutch, or driven wheel, that makes contact with the driving wheel, which is keyed to the crankshaft of the engine, is moved from the center of the latter over to its circumference the former will revolve at varying speeds.

Further, if the driven wheel is moved from one side of the driving wheel to the other side it will have its direction of rotation reversed. A reference to *A* in *Fig. 50* will show how these actions take place.

The Gearset Transmission.— There are two kinds of change-gear transmissions used in tractor transmission systems and these are (1) the *sliding gear transmission* and (2) the *planetary gear transmission.* Gear transmissions have from 1 to 4 speeds forward and from 1 to 4 speeds reverse, but nearly all tractors are provided with transmissions that give 2 speeds forward and 1 reverse.

The Sliding Gear Transmission.— In this transmission there are three shafts used and these are (a) the *countershaft* for the forward speed gears, (b) the *second countershaft,* sometimes called the *secondary shaft,* for the reverse gears and (3) the *drive shaft.*

On the countershaft there is rigidly fixed to, or *keyed,* three gears as shown at *A* in *Fig. 51.* On the drive shaft are two movable gears that can slide along it as it is *splined,* that is grooved lengthwise, and, hence, while the gears can slide they must turn with it just as though they were keyed to it. In the diagram *A* these gears are numbered, *1*, *2*, *3*, *4*, and *5*, *6*, respectively.

The gear *1* on the countershaft meshes with, and is driven, by the gear *2* on the clutchshaft which is connected to the engine through the clutch. The gear *3* on the countershaft is driven by the gear *4* when the latter is shifted into mesh with it by the *gear-shift yoke* which is fixed to and thrown by the *gear-shift lever* at the will of the tractioneer. The gear *5* on the *countershaft* meshes in the same way with the gear *6* on the splined shaft when the gear-shaft lever is thrown but when the gear *4* is moved over by the yoke the gear *6* moves also so that only one of these gears can mesh with its complementary gear at a time.

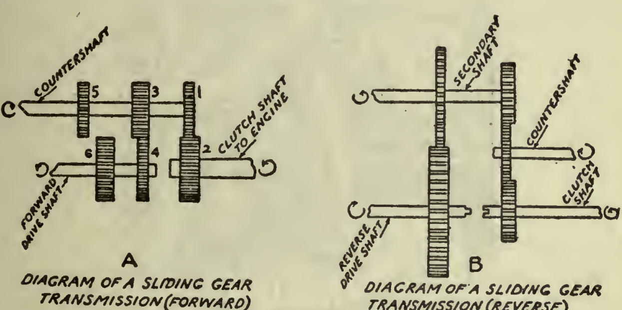
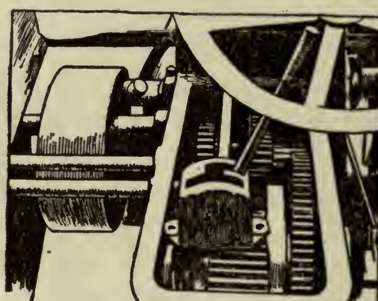


FIG. 51A, B.—HOW THE SLIDING GEAR TRANSMISSION IS MADE AND WORKS

Since the gears *3* and *4* and *5* and *6* are of different sizes it must be clear that the drive shaft which propels the tractor will revolve at two different speeds depending on which set of gears are in mesh, and, consequently, by shifting the gear-shift lever you can get either speed you want. If a third speed is wanted still another pair of gears must be put on the counter and drive shafts.

To reverse the tractor, that is, to back it up, a second countershaft must be used and this is geared to the clutchshaft and driveshaft as shown at *B*. Because of this second countershaft when the gears on it are shifted to mesh with the clutchshaft it makes the driveshaft rotate in the opposite direction.

Some gear transmissions use only spur gears as in the *Avery* tractor, and this is possible where the crankshaft of the engine sets parallel with the axles of the



C - THE SLIDING GEAR TRANSMISSION ON A TWIN CITY TRACTOR

FIG. 51C.— THE SLIDING GEAR TRANSMISSION

tractor, but beveled gears must be used to change the direction of the power where the engine crankshaft sets at right angles to the axles as in the *Wallis* tractor. The bevel gear is, however, just as efficient in transmitting power as the spur gear. The sliding gear transmission and gear-shift lever of a *Twin City* tractor is shown at *C*.

The Planetary Gear Transmission.— The outstanding feature that differentiates this transmission from the sliding gear transmission is that all of the gears are always in mesh. By looking at the drawing *A* in *Fig. 52,* you will see that the clutchshaft carries the *driving gear* and that there are three small gears, or *planet gears,* as they are called, because they revolve around the driving gear like the planets around the

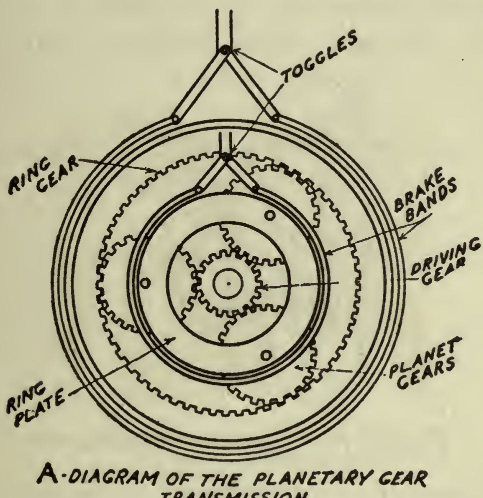
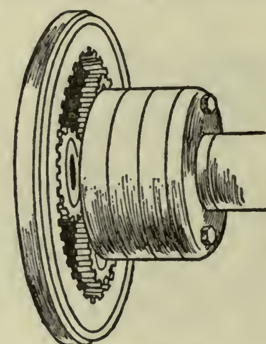


Fig. 52a.—How the Planetary Gear Transmission Is Made and Works

sun, that mesh with the latter and also with a large *internal,* or *ring gear.*

The planet gears rotate on pins that are fixed to the *ring plate* and around this and the large ring gear is a *contracting brake band* of the kind described in connection with the contracting band clutch. These bands are tightened and loosened by means of toggles, operated by a lever in the hands of the tractioneer in the same way as the sliding gear transmission.

Now the way the planetary gear transmission works is this: When both brake bands are loose all the gears will turn with the driving gear and this gives the highest speed forward. When, however, the brake band is tightened around the ring plate the drive gears carry the planetary gears around it; consequently,



B-PLANETARY GEAR TRANSMISSION ON LITTLE BEAR TRACTOR

FIG. 52B.—HOW THE PLANETARY GEAR TRANSMISSION IS MADE AND WORKS

since they are in mesh with the ring gear, it revolves and this gives the second speed forward.

But when the ring plate brake band is tightened around the ring gear it stops and the planetary gears, which rotate in the opposite direction to the ring gear, make the ring plate also move in the opposite direction and this gives the reverse speed. · It is shown at *B* in a *Little Bear* tractor.

The Counter and Intermediate Shafts.— Very often in reading about various tractors you will come upon the terms *countershaft* and *intermediate shaft.* These are the shafts that carry the transmission gears and, hence, they are located between the clutchshaft and the final driveshaft.

What the Differential is For.— As long as a tractor moves in a straight line both drive wheels, of course, revolve at the same speed. But when a tractor makes a turn the drive wheel on the outside has to cover more ground than the one on the inside. Now if both drive wheels are rigidly fixed to the same axle, or shaft, it is clear that the outside wheel will have to slip to keep up with the inside wheel when making a turn.

To keep the outside drive wheel from slipping and to give it the same traction resistance that the inside wheel exerts when the tractor is making a turn a mechanical movement called a *differential* is interposed between the two drive wheels. This scheme not only eases off the strain on the tractor but it permits it to make shorter turns. Where only one drive wheel, or drive drum, is used there is no need for a differential and this is the reason that tractors of this type are built, but a differential is an absolute necessity on a tractor that has two drive wheels.

Kinds of Differentials.— All *differentials* work on the same principle so that when you know how one of them works you will understand them all. The difference in differentials, then, is not one of principle, for all of them are *compensating gears* which permit the power to turn both drive wheels equally when the tractor is moving in a straight line, or to turn independently of one another when one wheel has to cover more ground than the other. The specific difference in differentials lies in (1) the kind of gears used, and (2) whether they can or cannot be locked.

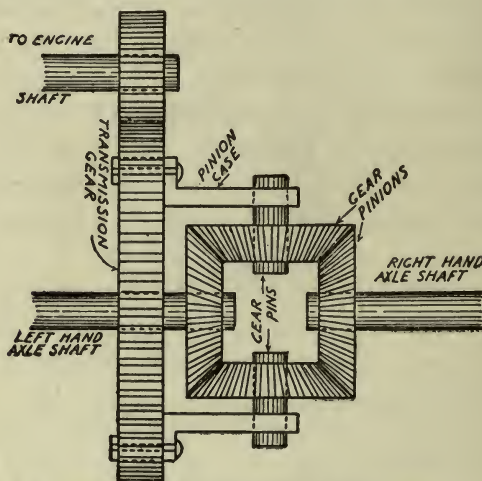
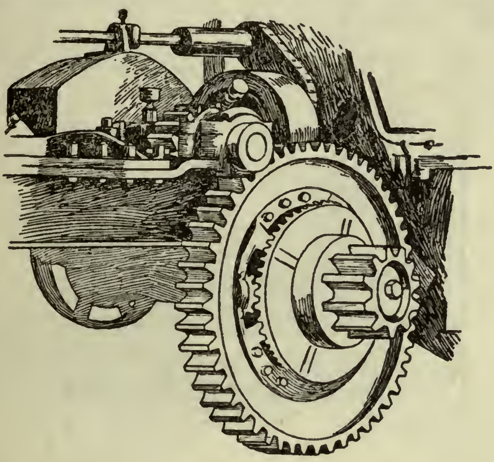


FIG. 53A.—HOW THE DIFFERENTIAL GEARS WORK

How the Differential is Made and Works.— You can easily understand how the *differential* is made and works if you will look at the diagram of the gears shown at *A* in *Fig. 53* and the actual differential on the *E-B* tractor as shown at *B*.

You will see from the diagram that a *drive gear* is secured to one end of the *drive shaft* and this meshes with and drives a *ring-gear*. To the ring-gear is fixed a *gear frame* and, hence, these revolve together. There are usually two *differential gears* used in tractor transmissions, and one of these is secured to one of the axle shafts and the other to the other axle shaft.



B - THE DIFFERENTIAL GEAR ON AN E-B TRACTOR

FIG. 53B.— HOW THE DIFFERENTIAL IS MADE AND WORKS

These shafts abut and are in alignment with each other as shown in the diagram.

The *differential pinions,* or small gears, of which there are usually three or four, are pivoted to the gear case and these mesh with the large gears that are keyed to the axle shafts.

It is easy now to understand how the differential works: when the axle shaft is driven by the large spur-gear, the beveled pinions, of course, turn round with it. If, now, the tractor is moving straight ahead, the distance of travel of both drive wheels will be the same and, hence, the power delivered to the spur-gear on the axle shaft will make all of the gears revolve together as though the drive shaft was a single

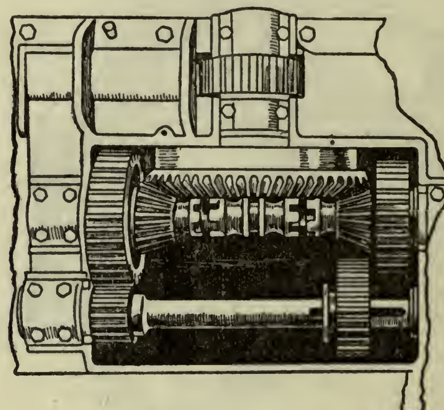


Fig. 54.— A Locking Differential

piece and when this is the case both drive wheels will revolve at the same speed.

But when the tractor makes a turn the beveled gear nearest the inside drive wheel will rotate more slowly than the one nearest the outside drive wheel; this is in virtue of the fact that the power driving the spur-gear makes the beveled pinions turn on their pins, yet at the same time it delivers power to both drive wheels. In the real differential shown at *B* three or more beveled pinions are fitted in a frame called a *spider* and this is fixed inside the spur-gear.

What a Locking Differential Is.— Since tractors usually travel comparatively long distances before they have to make a turn in plowing, etc., it is good engi-

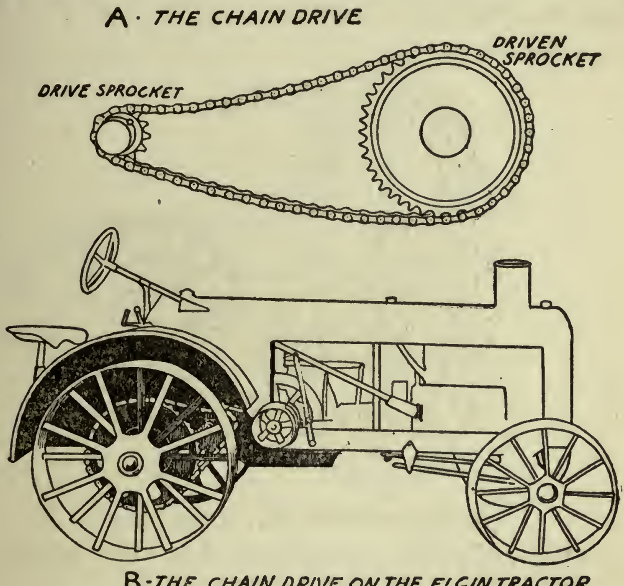


Fig. 55.— How the Chain Drive Works

neering practice to lock the opposite differential gears which operate the drive wheels and this is done by one or more *dog-clutches*.

These clutches can be thrown in and out of mesh as desired. When they are in mesh both drive wheels rotate as though they were fixed to a single axle.

When rounding a corner the clutches can be thrown out of mesh and the differential is then free to let them revolve as distinct members. *Fig. 54* shows a locking differential.

What the Final Drive Is.— There are very few tractors whose drive wheels are keyed directly to the

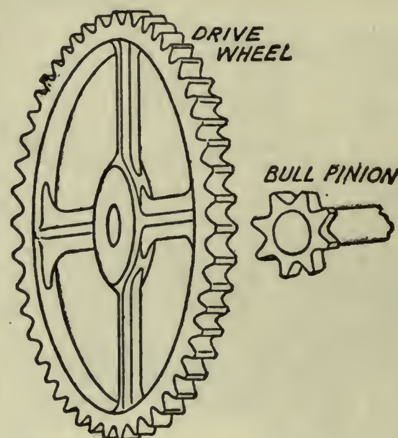


FIG. 56A.— HOW THE EXTERNAL BULL GEAR DRIVE IS MADE AND WORKS

drive shafts that are connected with the differential but instead the rear end weight of the tractor is usually carried by an axle and the drive wheels are driven from the drive shafts by some kind of a power transmitting scheme and this is called the *final drive.*

Kinds of Final Drives.— There are four kinds of final drives used on tractors and these are (1) the *chain drive;* (2) the *external bull gear drive;* (3) the *internal bull gear drive,* and (4) the *worm drive.* Further, these drives may be either (A) *open,* or (B) *enclosed.*

How Final Drives are Made and Work.— *The Chain Drive.*— The chain drive consists of a small *sprocket wheel* on each end of the countershaft that

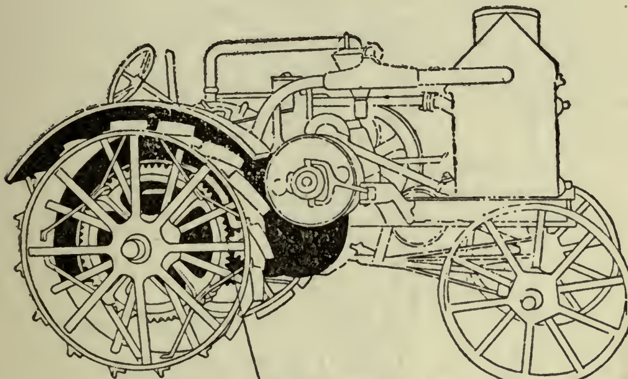


FIG. 56B.— HOW THE EXTERNAL BULL GEAR DRIVE IS MADE AND WORKS

carries the differential gear. Another and larger sprocket is fixed to each drive wheel and the sprockets are then connected by means of a drive chain as shown at *A* in *Fig. 55.* The chain drive on the *Elgin* tractor is shown at *B.*

The External Bull-Gear Drive.— In this drive a large gear with teeth cut on its outside circumference, which is called a *bull-gear,* is bolted to the center of the drive wheels. The small drive gear, or *bull-pinion* as it is called, is keyed to the shafts that carry the differential and meshes with the bull-gear. This type of drive is shown at *A* and *B* in *Fig. 56.*

The Internal Bull-Gear Drive.— In this drive the

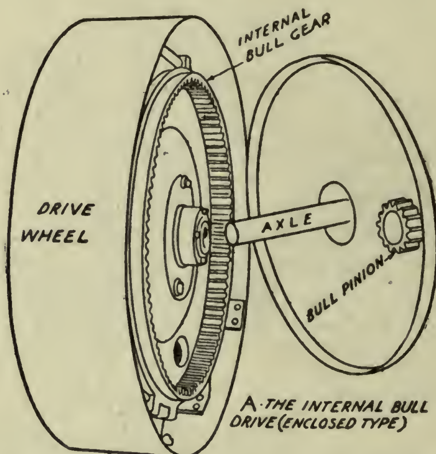


FIG. 57A.— HOW THE INTERNAL BULL GEAR DRIVE IS MADE AND WORKS

bull-gear is an internal one, that is, it is a ring-gear with teeth cut on its inner circumference as shown at *A* in *Fig. 57.* The small drive gear, or *bull pinion,* is coupled to the differential shaft as in the case of the external bull-gear drive, but, of course, it meshes with the bull-gear on the inside.

The Worm Drive.— A *worm-gear* is a screw whose threads mesh with the threads of a spiral gear as shown in *Fig. 58.* When the worm-gear is used for the final

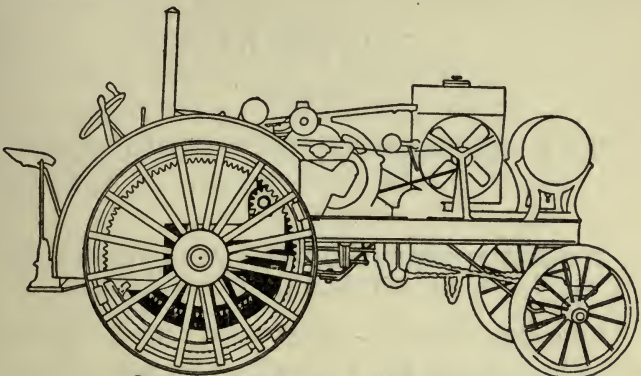


FIG. 57B.—HOW THE INTERNAL BULL GEAR IS MADE AND WORKS

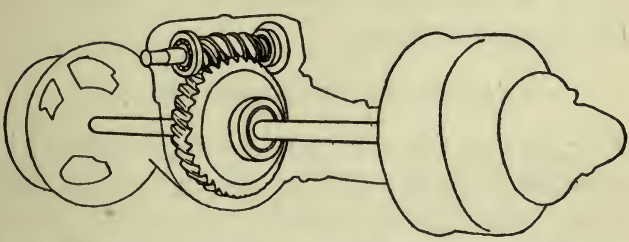


FIG. 58.—HOW THE WORM DRIVE IS MADE AND WORKS

drive the large spiral gear is made in the form of a ring-gear and the differential spider sets in and is fixed to it.

CHAPTER III

(Continued)

THE MECHANISM OF A TRACTOR

PART III

HOW THE STEERING GEAR AND BRAKES ARE MADE AND WORK

THE steering gear and brakes make up the two last mechanical devices that are used on tractors and both of these are quite simple in construction and, hence, easy to understand. As they are entirely different parts of the tractor mechanism I will describe them under separate headings.

ABOUT THE STEERING GEAR

Tractors that are fitted with wheels are steered by turning the front members to one side or the other like any other wheeled vehicle, but tractors of the crawler type are steered in a fashion all their own and this will be described presently.

How Wheeled Tractors are Steered.— There are three ways by which the front wheels of a tractor can be turned and these are (1) by *handles* when it turned by manual effort, like a push-cart; (2) by a *steering wheel gear* when it operated like a motor car or a motor truck, and (3) by *lines* when it is driven like a team of horses. Finally, the tractor can be automatically steered straight ahead when it is used for plowing by (4) a *guide rod,* or *wheel,* that sets into and follows the furrow.

Kinds of Front Axle Assemblies.— By *assembly* is meant the way in which the front wheel is, or wheels are, mounted on the axle or other supporting member so that it, or they, can be turned. There are three

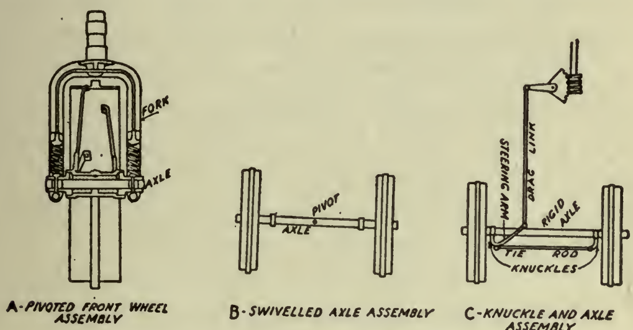


FIG. 59.— KINDS OF FRONT WHEEL ASSEMBLIES

kinds of assemblies employed in tractor construction that have front wheels for the steering members and these are (1) the *pivoted fork* assembly, (2) the *pivoted axle* assembly and (3) the *knuckle and axle* assembly.

The Pivoted Fork Assembly.— Where a single wheel is used for the steering member it sets in a fork and this turns on a vertical pivot like the front wheel of a bicycle as *A* in *Fig. 59* shows.

The Swivelled Axle Assembly.— Two wheels are used in this assembly and these are mounted on the ends of an axle which is pivoted to the front end of the tractor frame as shown at *B*. It is like the front axle assembly of a wagon, in that the axle and, hence the wheels, swings from side to side around the pivot.

The Knuckle and Axle Assembly.— In this assembly the rigid front axle always remains in the same position, that is, parallel to the rear axle. Each end of the axle carries a *knuckle* which is fixed to a stub axle and on this the wheel turns. The knuckles form hinged supports which permit the wheels to turn from side to side. Each knuckle is fitted with a *knuckle arm* and these are connected together by means of a *tie-rod*. A *steering arm* is fixed to one of the knuckles and this connects with a *drag link* all of which is shown at *C*. This is the standard assembly axle that is used in all motor cars and motor trucks and is also used on nearly all of the best tractors.

What the Steering Gear Consists Of.— The steering gear control is made up of (1) the *steering wheel,* (2) the *steering wheel shaft,* (3) the *steering gear proper* and (4) the *front axle assembly* described above, while (5) there is often one or more *universal joints* used in the steering wheel shaft.

The steering wheel is simply a large spoked wheel which the tractioneer turns one way or the other when he wants to steer his tractor to the right or left. To this wheel is fixed the steering shaft and this has a *worm gear,* or a *bevel pinion,* on its other end.

Whichever gear is used it meshes with either (1) a *spiral gear,* (2) a *nut,* or (3) a *sector.*

The Universal Joint.— This is a mechanical movement that is used to couple the steering shaft together where it is necessary to make a bend in the latter and yet allow it to revolve. A universal joint consists of two U-shaped yokes each of which are connected to the ends of the shaft where it is cut to form an angle, and the ends of the yokes are then pivoted together. Such a coupling allows both shafts to turn freely and together regardless of the angle they set at, nearly.

How the Steering Gear Control Works.— *The Single Wheel, Pivoted Fork Control.*— Where a single front wheel is used in a pivoted fork for steering the tractor, the upper end of the pivot is keyed to either (1) a *spiral gear* or a *bevel gear,* depending on whether a *worm gear* or a *beveled* pinion is fixed on the steering shaft, or (2) to a *grooved wheel.*

Where a spiral gear is used the end of the steering shaft is fitted with a small worm gear that meshes with it as shown in *Fig. 60.* But where a bevel gear is keyed to the end of the pivot the end of the steering shaft must be provided with a bevel pinion that meshes with the bevel gear on the pivot of the fork.

Where a grooved wheel is keyed to the pivot of the fork the bevel gear is mounted on an arm that is fixed to and projects from the bearing of the fork. This gear also has a groove cut in its periphery, or rim, and a chain, or cable, is looped around it and the grooved wheel, and then drawn up tight. In this case also the steering shaft has a beveled pinion that meshes with the bevel gear which carries the chain or cable.

It is obvious, now, that when the tractioneer turns the steering wheel the motion is transmitted by the shaft to the bevel pinion or worm and by the latter to the bevel gear or spiral gear on the pivoted fork

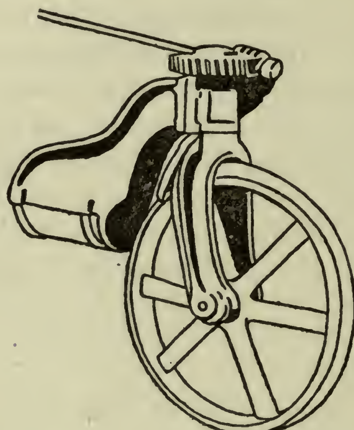


Fig. 60.—The Steering Gear Mechanism for a Single Front Wheel

assembly. Where the grooved wheel is used it is, of course, rotated by the bevel gear through the chain or cable.

The Double Wheel, Swivelled Axle Control.—Where the front end of the tractor frame is pivoted to the middle of the axle, the latter and, hence the wheels, are turned to the right or left by chains which wind on a *drum* in opposite directions. The drum is rotated by a worm on the steering shaft that meshes with a spiral gear on the former. When the steering wheel is turned one way or the other the worm gear rotates the drum accordingly and the chain on one side winds up while the one on the other side unwinds, thus turning the axle and the wheels either way as desired. It is shown in *Fig. 61.*

The Double Wheel, Knuckle Control.— In this steering arrangement the steering wheel works either a

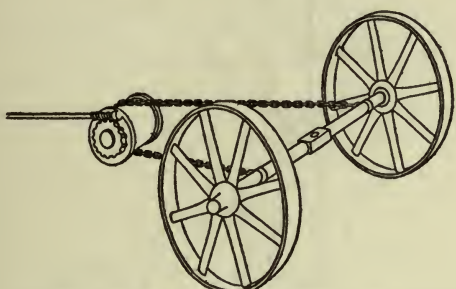
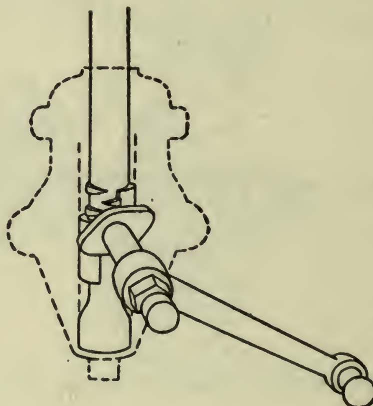


Fig. 61.— Double Wheel Swivelled Axle Control

worm and nut gear as shown at *A* in *Fig. 62*, or a *worm* and *sector gear,* as shown at *B,* at the end of the steering shaft. Where a worm and nut gear is used the nut is moved up and down as the steering shaft is turned by the steering wheel.

Where a worm and nut gear is used one end of an arm is fixed to the nut, see *A,* and the other end of the arm is pivoted to the drag-link, which, as described under the heading of *The Knuckle and Axle Assembly,* and shown at *C* in *Fig. 59,* is connected with the steering arm of the knuckle. Now when the steering wheel is turned the worm on the end of the steering shaft screws the nut on it up or down; this raises or lowers the nut which pulls up or presses down the arm that is connected with the drag link and this turns the steering knuckles too and fro.

But where the worm and sector gear is used the



A - WORM AND NUT GEAR

FIG. 62A.— KINDS OF STEERING GEARS

worm on the end of the steering shaft turns the toothed sector which is a section, or *arc,* of a spur-gear; as this carries an arm that is connected with the drag link, when the steering shaft is turned the worm screws the toothed sector around and this forces the drag link forth and back which turns the steering knuckles, and, consequently, the wheels, as I have

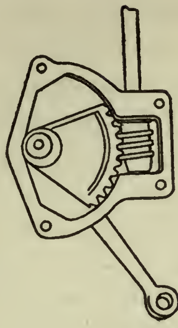


Fig. 62b.— Kinds of Steering Gears

described above. The arrangement is shown in *Fig. 63*.

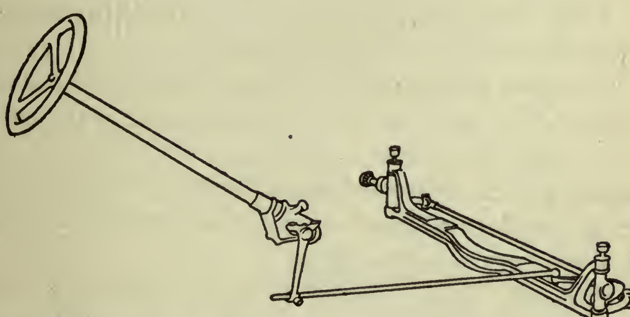


Fig. 63.— The Worm Steering Gear Coupled to the Knuckle Assembly

Line Steering Gear Control.— *How It Is Made.*— In the line controlled *Automotive* tractor the power to steer it, that is, to swing the front wheels around, is taken from the camshaft of the engine. From the camshaft the power is delivered by means of a pair of bevel gears to a *splined* shaft and on this are two cone clutches with a collar between them.

A shifting fork, which is held in place by a groove in the collar, keeps the clutches in a fixed position through a pair of springs. The shifting fork has a lever fastened to one end of it and which works at right angles to it; this shifting lever is connected with the clutch operating lever which ends in a T shaped head and the driving lines are fastened to the extreme ends of the T cross-head thus making it possible to steer the tractor no matter what position the clutch operating lever may be in.

At the end of the T shaped clutch operating lever is fixed an 8-tooth ratchet and on the other end of the shaft which carries it is keyed a cam having four points, thus giving eight positions, one for each tooth in the rachet and one for each space between the teeth. The clutch lever that operates on this cam, is connected with a *dash-pot*[1] and this allows the clutch to be operated at a speed of three seconds every other time the lines are pulled back.

How the Line Control Works.— The first four inches of pull on the lines retards the engine speed while the rest of the pull operates the clutch, and every pull alternately throws the clutch in and out — *in* when

[1] A dash-pot is a device to prevent the too sudden motion of the clutch lever. It is usually a piston working in a cylinder filled with glycerine

it is between the points of the cam and *out* when it is on the points.

The transmission gears are shifted by the use of two cams in the same way that the clutch is worked and while a third line is recommended by the makers for shifting the gears it can, however, be connected

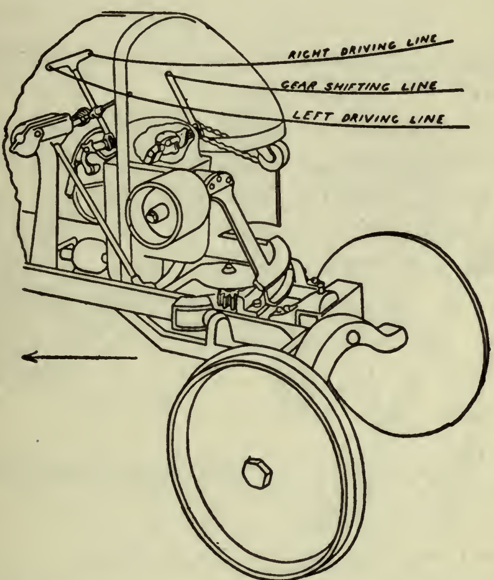


FIG. 64.—THE AUTOMOTIVE LINE STEERING CONTROL

to the steering lines but in this case more care must be taken to manipulate them.

The cams on the gear-shifting device work together at all times so that when one lever is being operated the other is held in place and the arrangement is such that one lever cannot be engaged until the other is in a neutral position. The *Automotive* line controlled steering gear is pictured in *Fig. 64*.

The Automatic Guide Wheel Steering Control. — In order to relieve the tractioneer from the strain

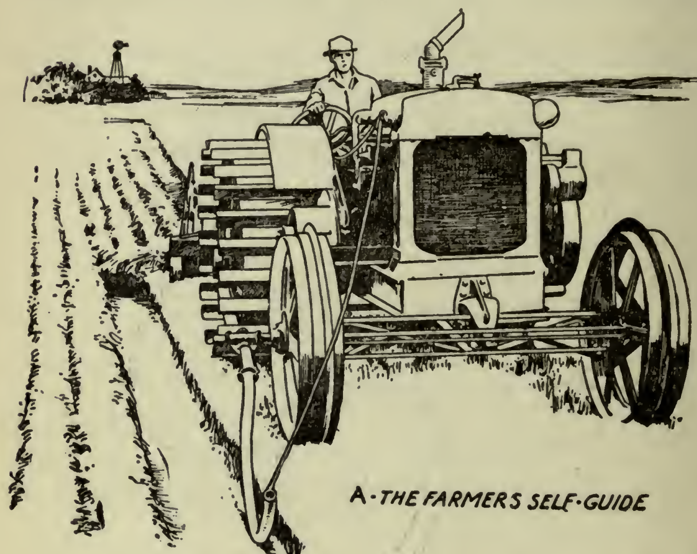
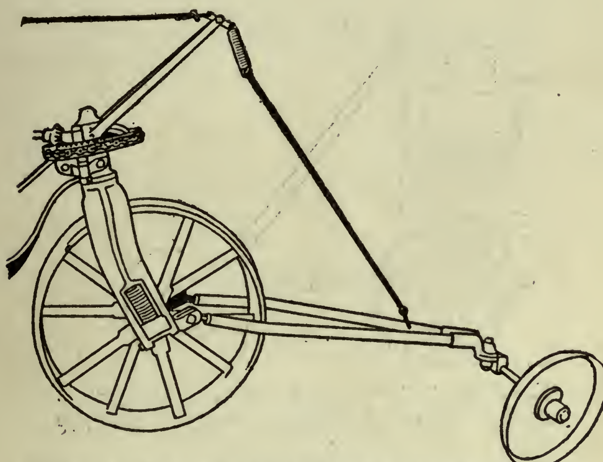


Fig. 65a.— Kinds of Self-Guides

of having to constantly steer the tractor in a straight line when plowing an automatic guide, or *self-guide,* as it is sometimes called, which can be attached to any tractor, is often used. The farmer's guide is simply a piece of bent pipe as shown at *A* in *Fig. 65*.

The guide, which is shown at *B,* where one wheel is used, and at *C* where two wheels are used, is formed of a *frame* whose rear end is connected with the front axle and a *disk furrow wheel* attached to the front end of the frame. The disk wheel drops into and follows the furrow and so keeps the tractor straight;



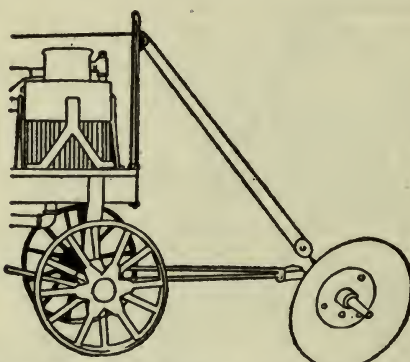
B-THE SELF-GUIDE ATTACHMENT FOR A SINGLE FRONT WHEEL TRACTOR.

FIG. 65B.— KINDS OF SELF-GUIDES

but when you come to the end and want to turn round or to move from one place to another, pull upon the rope and this lifts the disk from the ground.

How Crawler Tractors are Steered.— There are two schemes used for steering crawler tractors, namely, those that are (1) steered by one or two front wheels and those that are (2) steered by the crawlers themselves. Tractors having wheels and crawlers are steered by the same kind of a steering gear as the four wheel tractors, but with tractors having crawlers only the method of steering is quite different.

In a tractor where crawlers are the only traction members used they are operated independently of each



C - THE SELF-GUIDE ATTACHMENT FOR A DOUBLE FRONT WHEEL TRACTOR

FIG. 65C.— KINDS OF SELF-GUIDES

other and, hence, to turn the tractor one crawler is disconnected from the driving gear and the power is applied only to the other one. When this action takes place the shaft that drives the crawler runs twice as fast as when both crawlers are working together.

In some tractors one crawler can be reversed while the other is running ahead and in this way the tractor can be turned almost in its own length. The diagram at *A* in *Fig. 66* will give you an idea of how the crawl-

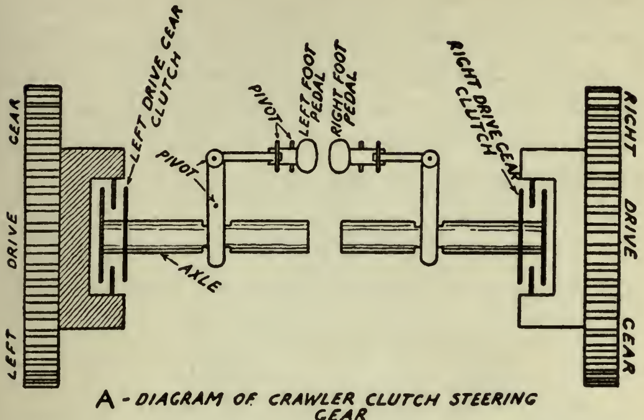


FIG. 66A.—HOW A CRAWLER TRACTOR STEERING GEAR IS MADE AND WORKS

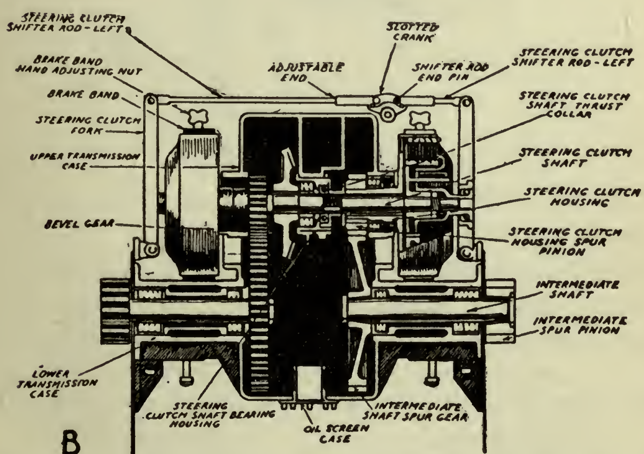


FIG. 66B.—CLUTCH STEERING GEAR OF A HOLT-CATERPILLAR 40–60 ers are worked, either together, or separately, by means of clutches. To steer the tractor the clutch is released on the shaft toward the side you want the tractor to turn and thrown in on the other side. *B* shows the steering clutch mechanism of a *Holt Caterpillar 40–60* mounted on a separate drive shaft.

ABOUT THE BRAKES

There are two kinds of brakes used on tractors and

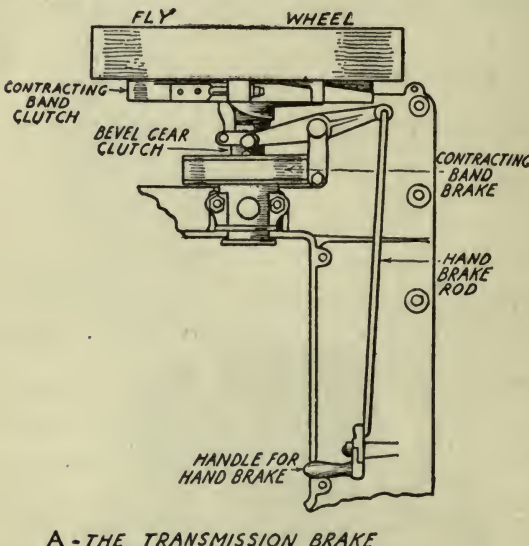
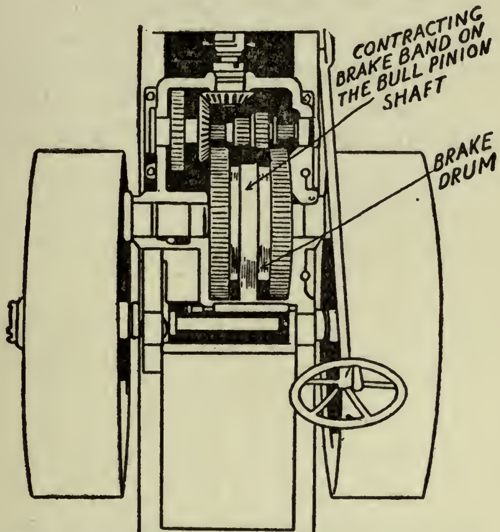


FIG. 67A.— THE TRANSMISSION BRAKE

these are (1) the *transmission brake* and (2) the *emergency brake.*

The Transmission Brake.— This brake is used to keep the transmission gears from spinning after you have released the clutch, otherwise you would have to wait for them to stop before you shift the gears.

In some tractors it is simply a block of wood that



B·THE EMERGENCY BRAKE ON A TWIN CITY TRACTOR

FIG. 67B.—THE EMERGENCY BRAKE.

presses on the transmission shaft when you pull the brake lever, while in others it is a cup and cone or a band clutch that is automatically applied when you release the transmission clutch. It is shown at *A* in *Fig. 67.*

The Emergency Brake.—This brake usually consists of a contracting band that grips a drum like that described under the heading of the *Contracting Band Clutch* in *Part II, Chapter III,* on *Page 105.*

When the brake is used the band is looped around a brake drum which is fastened to the low speed shaft that drives the bull gears. One end of the contracting band is fixed to the frame of the tractor and the other end is connected to a lever pivoted to a shaft which is connected either with a hand brake lever or a foot pedal. It is shown at *B* in *Fig. 67.*

CHAPTER IV

GARDEN AND TRUCK FARM TRACTORS

WHEN Edison said that the horse is the "poorest motor ever built" he missed the point by just one notch for of all the power producers, either animal, or mechanical, man is by long odds the worst of the lot.

But nature never intended that man should do manual work any more than she intended him to grow wings and fly; but to make up for the lack of these physical attributes he was given a creative brain and slowly, but surely, he made use of it to devise machines to do his work, just as he finally made a machine which enabled him to soar the empyrean blue.

With the advent of the internal combustion engine the trend of the times was to do away with the horse as a means of transportation and it followed, in the natural course of events, that a machine should be built which would not only do all the heavy work a horse can do on the farm but a lot of other things the horse was not designed to do. Then a brilliant idea was developed in the convoluted mass of the cranium of some super-intelligent genius who wanted to make some money and he devised a small walking tractor which would all but eliminate man as a power factor in the cultivation of his little lands, and here it is in all its variations.

What the Garden Tractor Is.—A *garden tractor* is a miniature tractor modeled along the lines of its big brother, the farm tractor, but instead of riding on it the tractioneer walks behind it and instead of steering it with a wheel, levers or lines, he simply guides it by a pair of projecting handles in the same way that he would do with a horse-drawn plow or cultivator.

Makes of Garden Tractors.— There are only four or five garden tractors on the market at the present writing and all of them are made, work and operate in practically the same way. In other words, the design of garden tractors is pretty well standardized though all of them differ in details of construction as well as in height, width and wheel-base, the size and power of the engine, the cooling and ignition systems and, finally, in the price.

The Merry Garden Auto Cultivator.— This garden tractor is the smallest and cheapest one made and it is intended for the home garden more than it is for the truck garden. It is made by the *Atlantic Machine* and *Manufacturing Co.*, 429 Prospect Avenue, S. W., Cleveland, Ohio, and it sells for $185 [1] without attachments.

How it is Made.— First of all it has only two traction members and both of these are drive wheels; as

[1] All prices given in this book are subject to change.

they also serve to support the tractor it must be kept in the proper position by the tractioneer. This is done by means of a pair of plow-like handles that are fixed to the frame. It is shown at *A* and *B* in *Fig. 68.*

The wheels have a 3-inch face, though wheels having a 5-inch face can be used for sandy soils, but in either case they are 20 inches in diameter. As there

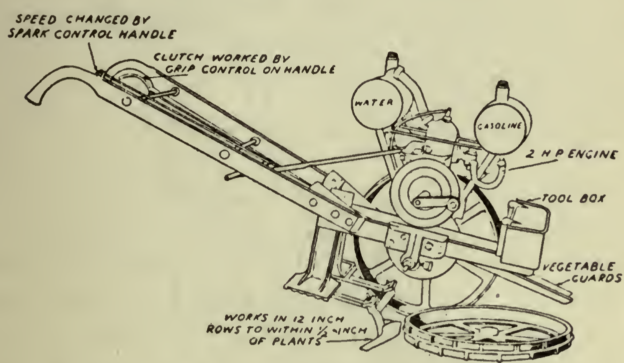


FIG. 68A.—THE MERRY GARDEN TRACTOR DISSECTED

are only two wheels 100 per cent. of the weight of the tractor rests on them and as it weighs 250 pounds this gives it a fair traction resistance. The clearance is 9 inches to the axle and it straddles a row that is 12 inches wide.

The engine is of the vertical type, has one cylinder and when running at its normal speed, which is 900 revolutions per minute, it develops about 1 draw-bar and 2 belt horse power. It has the splash system of lubrication and is water cooled by the thermo-siphon system; a 5 quart cylindrical water tank is mounted above the wheels and is connected to the jacket of the engine cylinder by a couple of short lengths of pipe, but the action is exactly like that of a hopper water cooled engine.

The fuel used is gasoline and the tank, which also

Fig. 68b.—Cultivating Beets with the Merry Garden Tractor

holds 5 quarts, is, likewise, mounted on top of the tractor and parallel with the water tank. The tractor will run from 4 to 8 hours on a gallon of gasoline depending on the work it is doing. A magneto system of ignition is used to fire the fuel charge in the cylinders.

The handles are adjustable so that they can be held by a boy or a man. On the right handle there is a control lever which gives a change of speed, and on the left there is a clutch control lever so that the drive wheels can be thrown into or out of gear with the engine.

The Draw-bar Pull.— The tools that can be used with this little tractor are (1) a 4-inch plow, (2) a 4-inch double moldboard plow, (3) a covering plow, (4) a pair of hoes, (5) a rake, (6) narrow or wide cultivator teeth, (7) a three prong cultivator, (8) disk hoes, (9) an onion digger, and (10) a lawn mower with 30-inch knives can also be fitted to it.

The speed of the tractor when used as a cultivator is about 120 feet per minute and this is just about equal to the work that four men can do with hand cultivators.

The Power Take Off.— The engine has a power take off and where it is wanted a pulley is furnished by the company at a small extra cost. The engine can then be used to operate a churn, separator, saw and other small contrivances.

The Beeman Garden Tractor.— This tractor is made to do the work in a truck garden that is usually done with a horse. It is built by the *Beeman Garden Tractor Co.,* Minneapolis, Minn., and it is sold for $285.

How it is Made.— The traction members of this tractor consist of two drive wheels with a face of 3½ inches and a diameter of 25 inches. It is ordinarily equipped as a lift tractor but large castor wheels can be used to sustain the rear-end weight, and where the ground is rough they can be extended on either side of the tractor. Where the drive wheels only are used 100 per cent. of the weight rests on them, of course, but where the castor support wheels are used the weight on the drive wheels is about 80 per cent.

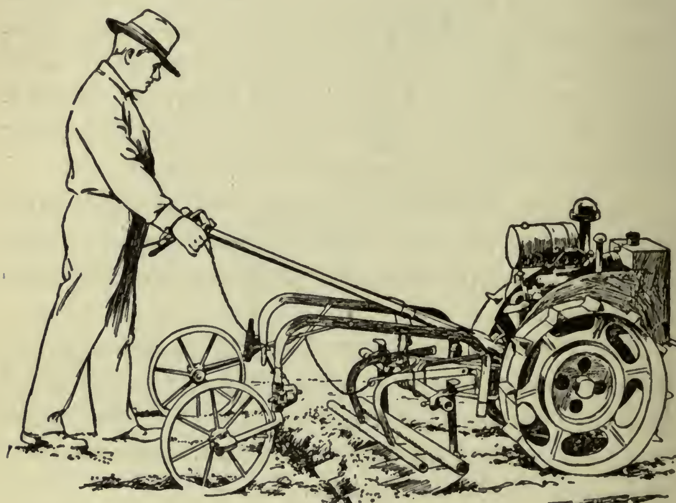


Fig. 69.—The Beeman Garden Tractor

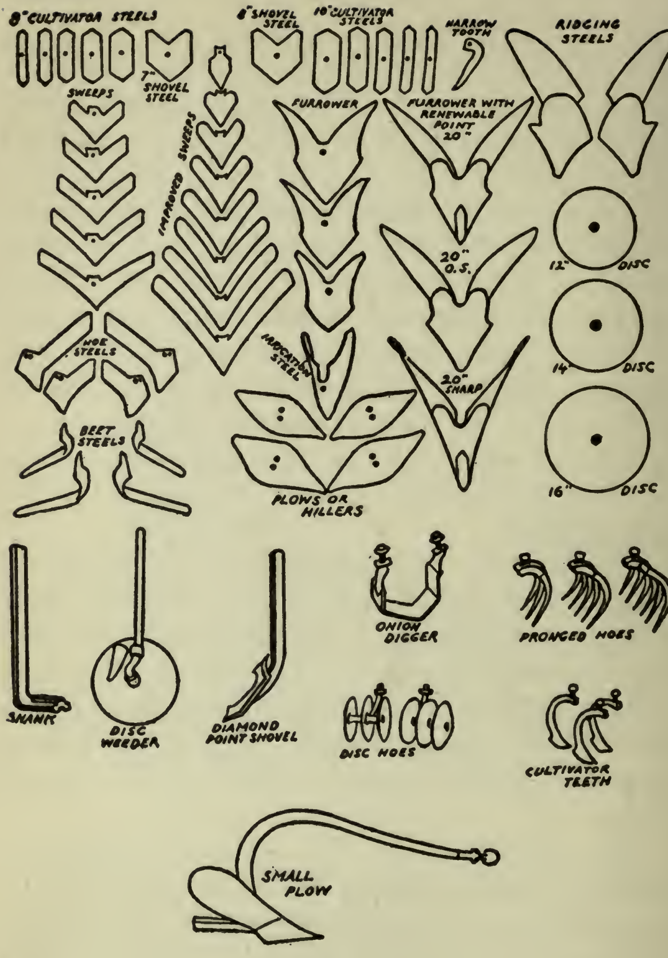
The tractor is 17 inches wide, 39 inches high and weighs about 537 pounds and this is sufficiently heavy to insure a good traction resistance. The highest adjustment of the draw-bar is 11 inches and the lowest is 9 inches, while the straddle is 11 inches.

You steer the tractor by means of a pair of handles and on the right hand is a lever that controls the throttle which you work with your thumb and forefinger, while on the left hand one is the clutch lever which you can release with your little finger as shown at *A* in *Fig. 69*.

The engine has a single cylinder and is of the vertical type and when it is connected to the drive wheels it will develop 1¼ horse power at the draw-bar and deliver 4 horse power at the belt. It runs at a speed of from 230 to 2,000 revolutions per minute, depending on the amount of fuel that you give it, but its normal speed is 1,250 revolutions per minute. A gallon of gasoline will run the engine when working in the field for about 5 hours and on the belt for about 7 hours.

The engine is lubricated by the splash system and it is cooled by the thermo-syphon system, the water being forced through a large cellular radiator on the front of the tractor. The gasoline is fed to the carburetor by the gravity feed system from a 1 gallon tank that sets above the engine while a high tension magneto ignition system is used to fire the fuel charge.

The Draw-bar Pull.— The cultivator attachments that can be used by hitching them to the tractor are (1) a 7-inch plow, (2) a 6-inch harrow, or an 8-blade, 12-inch disk harrow, (3) sweeps, (4) disks, (5) a knife weeder, (6) disk hoes, (7) diamond pointed shovel, (8) a corn shovel, (9) a spring tooth for cultivating, (10) beet hoes, (11) a bull tongue, (12) an onion



A

Fig. 70a.— Some Tools Used with Garden Tractors digger, etc., and all of which are shown at *A* and *B* in *Fig. 70*.

Any ordinary one-horse plow can be used by taking off the handles and clevis and hitching it to the tool frame of the tractor. When the plow is hitched up

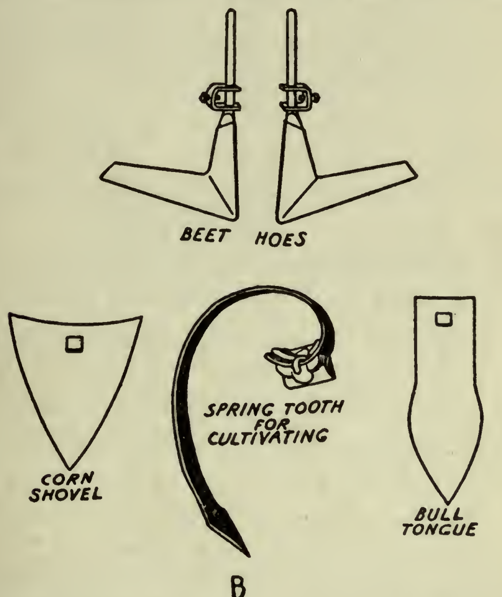


FIG. 70B.—SOME TOOLS USED WITH GARDEN TRACTORS

right it will give not only the depth and width you want but when it is properly adjusted the tractor will hold to the furrow and you have only to follow along until you come to a corner and then turn it.

To take the plow from the ground you simply lift up on the handles of the tractor and this raises the point of the plow when it quickly comes to the surface; a latch catches and holds the plow up and it will then slide on its heel along the ground. When you want to plow again all you have to do to start the point into the ground is to pull up a small trip chain which is fastened to the spring latch and this brings it at an angle so that it will dig in and it will go in to whatever depth you adjust it for.

The speed of the tractor when plowing is from ¾ to 2½ miles per hour depending on the soil and it only takes about 2 gallons of gasoline to plow right along for 10 hours.

The Power Take Off.— The Beeman tractor will do anything in the way of *belt* work that any four horse power engine will do and, different from a stationary engine, it will do it anywhere.

With the power take off you can run a feed grinder, pump-jack, washing machine, milking machine, cream separator, fanning mill, onion topper, feed cutter, circular saw, corn sheller, grindstone, emery wheel, and even a small electric lighting plant.

The Universal 1–4.9 Tractor.— This truck garden tractor is a little bigger all round than the tractor just described and, consequently, it will do work that is proportionately heavier. It is built by the *Elderfields Mechanics Co.,* Port Washington, Long Island, New York, and costs $425.

How it is Made.— The *Universal* garden tractor has three traction members, two drive wheels in front and one small support wheel in the rear. The drive wheels are 36 inches in diameter, have a 5-inch face and 75 per cent. of the weight rests on them. It has a length of 84 inches, a width of 33½ inches, a height of 42 inches and it weighs 750 pounds. Further, it has a wheel-base of 84 inches, a clearance of 12 inches and a turning radius of 2 feet. It is steered by a pair of handles while the clutch is operated and the fuel supply is controlled by levers on the former.

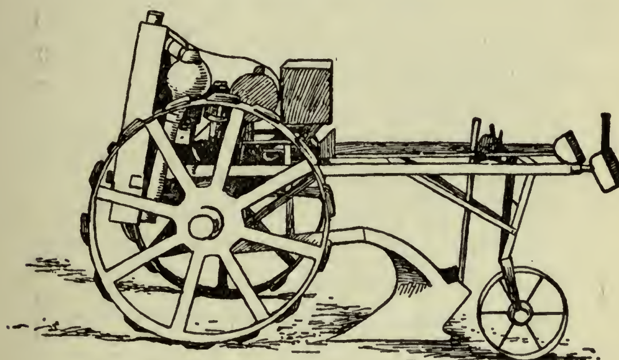


FIG. 71.—THE UNIVERSAL GARDEN TRACTOR

The engine is of the vertical type, has a single cylinder with a 3½ by 5-inch bore and it runs at a normal speed of 800 revolutions per minute but it can be run at from 500 to 1,000 revolutions per minute by giving it less or more gas. It is lubricated by the splash system, has a gravity feed fuel system and either gasoline or kerosene can be used while its fuel tank will hold 4 gallons.

It is cooled by the thermo-syphon system, has a cellular radiator and a fan. A storage battery circuit breaker system is used to fire the fuel charge and hence you must have an electric lighting circuit to charge the battery with. Finally, the crankshaft of the engine is connected to the drive axle by means of a worm and gear and this gives the tractor one speed forward though this can be varied by making the engine run faster or slower. It is shown in *Fig. 71.*

The Draw-bar.— The *Universal* has a normal draw-bar pull of 200 pounds and it will pull one 10-inch plow. The draw-bar is fixed to the tractor 13 inches from the ground and the plow is hitched to it between the drive wheels and the support wheel. All the other attachments cited above for the Beeman tractor, only on a somewhat larger scale, can be used with this tractor. It can be used not only in gardens but to clean up the corners of a big farm where a large tractor cannot go.

The Power Take Off.— The belt pulley has a 2-inch face and is 5¼ inches in diameter and it will deliver 4 horse power when the engine is running at its normal speed of 800 revolutions per minute and more when it is running faster. It will, of course, run all kinds of belt machinery that does not take in excess of 4 horse power.

The Auto-Tiller.— This tractor is built right along the lines of the one just described, but it is a trifle larger, is better equipped and will take the place of a team of horses on the farm. It is made by the *World*

Harvester Corporation, New York City, and its price is $465.

How it is Made.— It has two drive wheels 36 inches in diameter with a 5-inch face and a pair of small support wheels in the rear. Its wheel-base is 36 inches and 70 per cent. of the weight of the tractor rests on the drive wheels, while its turning radius is 6 feet. Its length is 115 inches over all, its width is 40 inches, its height 46 inches and its weight 1,150 pounds.

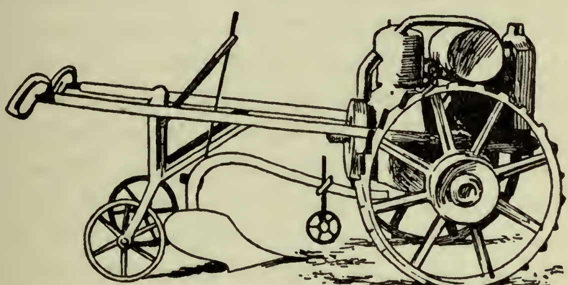


FIG. 72.— THE AUTO-TILLER GARDEN TRACTOR

Finally, it is steered by means of handles and its clutch and throttle are controlled by levers on them. This tractor is pictured in *Fig. 72.*

The engine is of the vertical type, has one cylinder whose bore is 5 x 7 inches and develops 4.9 horse power. It is lubricated by the splash system, has a tubular radiator and is cooled by the pump circulating system and a fan. Either the magneto or the storage battery circuit breaker system is used for ignition according to your preference. When the latter is used don't forget that the battery requires constant care and must be kept charged and that it takes an electric light current to do it with.

The crankshaft of the engine is connected to the final drive, which is of the worm and gear type, by a contracting band clutch, and a sliding gear transmission. The tractor has two speeds forward, namely, 1½ and 3 miles per hour.

The Draw-Bar Pull.— The draw-bar of this tractor is fixed to the frame 15 inches above the ground. It has a normal draw-bar pull of 975 pounds and it will in consequence pull one 14-inch plow. The plow is hitched to the draw-bar between the drive wheels and the support wheels. All the farm implements that a team of horses can pull can be used as well or better with this tractor. It can be hitched to a light riding plow when the tractioneer can ride and this puts it very closely in the class of the regular farm tractor. Under such conditions it has a speed of about 2 miles per hour.

The Power Take Off.— As the engine develops 5 horse power, nearly, it can be used for all manner of light belt work.

CHAPTER V

TRACTORS FOR SMALL FARMS

WITH the idea of meeting the demand for a tractor that would permit it to be used economically on a small farm a few manufacturers are making a one-plow machine that sells at a low price.

The specifications which I have given in this chapter cover all of the tractors that I know of whose makers recommend their use with a single plow. As you will see these tractors take on a wide diversity of design and construction in the efforts of the builders to provide a machine that shall at once be useful for all the varied purposes of farm work, easily handled, have good wearing qualities and, last but not least, have a low initial cost.

How well they have succeeded may, in a measure, be gathered from the text that follows but never was the ancient Roman expression, which tells us that the "proof of the pudding is in the eating," so thoroughly exemplified as in the tractor, and especially in the one-plow tractor, for about the only way to actually find out how well it is adapted to your needs is to buy one and try it out yourself.

The Indiana 5–10 Tractor.— This is a new, light weight and inexpensive tractor. It is designed to take the place of a team of horses and to do all manner of light belt work. It is made by the *Indiana Silo Company,* of Anderson, Ind., and it sells for $900.

How it is Made. The Traction Gear.— The frame of this tractor is built up of structural steel, the front axle is drop-forged and the frame is rigidly fixed to it. A live rear axle is used and both axles are roller

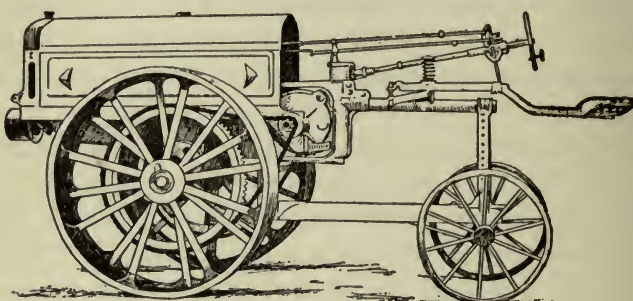


FIG. 73.— THE INDIANA 5-10 TRACTOR

bearing. The drive wheels are in front and these are 50 inches in diameter and have a 12-inch face while the two rear wheels are 36 inches in diameter and have a 4-inch face. The wheel-base is 62 inches and the turning radius is 7 feet.

The *Indiana* has a length of 212 inches, a width of 54 inches, a height of 60 inches and it weighs 2,000 pounds, of which 95 per cent. is on the drive members. The height of the draw-bar, which is swivelled, is 28 inches and the clearance at the lowest point is 26 inches.

The Power Plant.— The engine is of the vertical type with four cylinders, the bore of which is 3⅛ by 4½ inches, has an L head and is cast in block.[1] Its normal speed is 950 r. p. m. It has an enclosed centrifugal governor to control the speed of the engine.

The engine is lubricated by the force feed system and a plunger pump keeps the oil in circulation. The cooling scheme includes a cellular radiator and the water is kept in circulation by the thermo-siphon system and a ball-bearing, belt-driven fan. Gasoline is the fuel used and this is delivered by the gravity system from a 12-gallon tank to the carburetor. An air cleaner is attached to the inlet of the carburetor and the exhaust gases heat the air before it enters the mixing chamber.

A dual system of ignition is used and this includes the battery and circuit breaker system and a magneto.

The Transmission System.— This is made up of a disk clutch, an enclosed sliding gear transmission, with ball bearings, which gives four speeds forward and one reverse and a range of speeds from 1¼ to 4 miles per hour. The differential is enclosed, has beveled gears and is ball bearing, while the final drive is by means of a chain and sprocket. All the gears are made of steel, are machined and heat treated. It is shown in *Fig. 73*.

The Draw-bar Pull.— The normal draw-bar pull of this tractor is 900 pounds.

The Power Take Off.— The pulley has a diameter of 7 inches and a face of 6½ inches, and when the engine

[1] From the French *en bloc* which means all in one piece.

is running at 1,200 r. p. m., it will deliver 10 horse power.

The General Purpose 6–12 Tractor.— To produce a tractor that would do all the work on a small farm the *Allis-Chalmers Manufacturing Co.,* Milwaukee, Wis., put the *General Purpose* tractor on the market. Its price is $795.

How it is Made.— The Traction Gear.— This tractor has three traction members, two of which are drive wheels in front and one small truck wheel, which can be taken off, in the rear. The drive wheels have a 6-inch face and a diameter of 48 inches and these are keyed to a stub axle the bearings of which are plain. The width of the tractor is 54 inches, its height 72 inches and its weight is 2,100 pounds while the weight on the drive wheels is 90 per cent. It is steered by turning the drive wheels.

The Power Plant.— The engine is of the vertical type, has four cylinders with a bore of 3½ by 4½ inches, and an L head which is removable. The normal revolutions per minute of the engine is 1,000 and at this speed it develops 12 horse power. The engine is also fitted with a centrifugal governor to keep the speed of the engine uniform.

The splash system of lubrication is used and the oil is poured into the reservoir as it is needed. The cooling scheme includes a tubular radiator through which the water is kept circulating by the thermo-siphon system while a belt driven fan pulls the air through the radiator. The magneto system is used for ignition.

The fuel recommended is gasoline and this is fed by gravity from a 9 gallon tank while a dry air cleaner is fixed to the carburetor.

The Transmission System.— The clutch that connects the engine to the transmission gears is of the dry plate type. The transmission, or gear-set, has sliding gears and this gives the tractor one speed forward and one reverse. To vary the tractor speed the governor must be adjusted to give a different engine

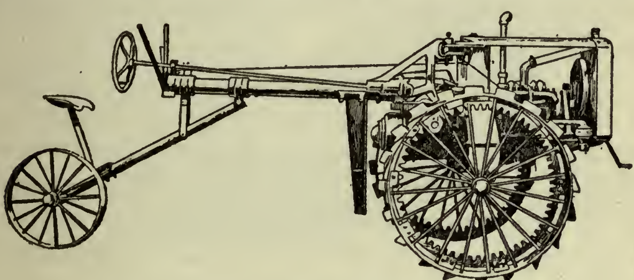


FIG. 74.— THE GENERAL PURPOSE TRACTOR

speed. Tractor speeds of from 1¾ to 2.8 m. p. h., can thus be had.

The differential gears are enclosed and these transmit the power to the final drive which is of the internal bull-gear type. The gears of the transmission and differential are machined and heat treated and the transmission and the fan are ball bearing. Finally, the steering gear is of the worm and segment type. A picture of it is shown in *Fig. 74*.

The Draw-Bar Pull.— The draw-bar has a normal pull of 1,000 pounds at a speed of 2½ miles per hour.

The Power Take Off.— The face of the pulley is 5½ inches and its diameter is 10 inches. It is driven from the crankshaft by a gear and the pulley clutch is of the dry plate type.

The E. F. T. 6–12 Crawler Tractor.— In the early days of tractor building the crawler was made only in large sizes but every year sees smaller crawlers in the market. The *E. F. T. 6–12* is the smallest crawler that has been built and it is made by the *E. F. Townsend Tractor Company* of Los Angeles, Cal. It sells for $850.

How it is Made.— The Traction Gear.— The frame of this little crawler is built up of structural steel. The front axle is drop forged, a dead drive axle is used and both have plain bearings. The frame is mounted on the front axle on a semi-elliptic spring.

The traction members consist of two crawlers each of which are 60 inches long, have a 7-inch face and a traction surface of 602 inches, while it has a wheel base of 43 inches and a turning radius of 6 feet. It is steered by a pair of levers that control a pair of clutches on the drive shaft.

The length of the tractor is 85 inches, it has a width of 50 inches and it weighs 2,000 pounds, and 100 per cent. of it is on the crawlers. It has an adjustable draw-bar that can be varied in height from 7 to 20 inches and a clearance of 9 inches. A rear extension provides a seat for the tractioneer and this is supported by a small wheel as shown in *Fig. 75*.

The Power Plant.— The engine has four cylinders with a $3\frac{1}{4}$ by $4\frac{1}{2}$ inch bore. It is of the vertical type, cast in block and has an L head. Its normal speed is 1,000 r. p. m., and it is controlled by a centrifugal governor.

It is lubricated by the force feed and splash system, the oil being circulated by a gear pump. The cooling system includes a cellular radiator and the water is kept in circulation by the thermo-siphon system with

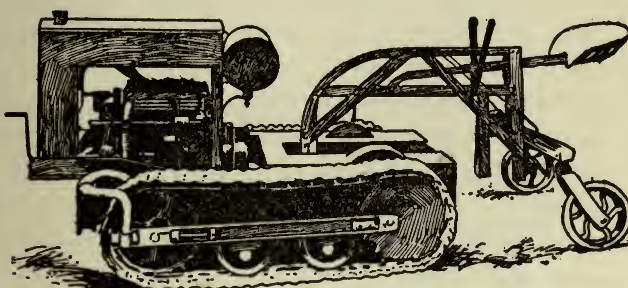


FIG. 75.—THE E. F. T. 6-12 CRAWLER TRACTOR

a fan to aid the cooling process. Any kind of liquid fuel can be used though, of course, gasoline or kerosene is to be preferred. The fuel is fed by the gravity system from a 10-gallon tank to the carburetor. A dry air cleaner is attached to the carburetor and the exhaust gases are used to heat the air as it is drawn in the latter.

The Transmission System.— The clutch is of the dry plate type and a sliding gear transmission provided with roller bearings is used. There is no differential and the final drive is an internal gear. The gears throughout are made of carbon steel, machined and heat treated.

The Draw-Bar Pull.— This tractor has a normal draw-bar pull of 1,000 pounds.

The Power Take Off.— There is none.

The Cultitractor 2F–15.— This tractor is made by the *United Tractors Company, Inc.,* New York City, and it sells for $785.

How it is Made.— The Traction Gear.— The frame of the *Cultitractor* is a one-piece casting, the front axle is drop forged and a live rear axle is used. The front traction members are the drive wheels and these are 40 inches in diameter with an 8-inch face, while the small wheels which are 30 inches in diameter have a 4-inch face and these support the rear end of the frame. The wheel base is 90 inches and the turning radius is 4½ feet.

The length of the tractor is 120 inches, its width is 52 inches, its height 54 inches, its weight 2,300 pounds and 95 per cent. of the latter rests on the drive wheels. The draw-bar can be adjusted so that it is 16 to 20 inches high and the clearance is 18 inches.

The Power Plant.— The engine is of the vertical type, has four cylinders, with a bore of 3¼ by 4½ inches, an L head and is cast in block. The normal speed of the engine is 1,000 r. p. m. and this is controlled by an enclosed governor of the centrifugal type. The force feed and splash system of lubrication is used. The cooling apparatus includes a cellular radiator and the water is circulated by the thermo-siphon system and the air by a fan.

Any kind of liquid fuel can be used and two 6-gallon tanks are provided for it, one for gasoline and the other for kerosene. The fuel is fed to the carburetor by gravity and is vaporized by the heat of the exhaust gases carried around the intake manifold. The carburetor is fitted with a dry air cleaner. The ignition is by the high tension magneto system.

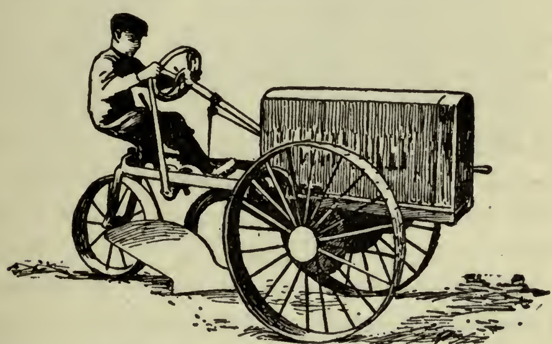


FIG. 76.— THE CULTITRACTOR 7–15

The Transmission System.— The clutch is of the dry plate type, the transmission gears give two speeds forward and 1 reverse, so that a range of speeds of from 1½ to 3 m. p. h. can be had without changing the adjustment of the governor. No differential is used and the final drive is by an internal bull-gear. The gears are made of cast steel, machined and case hardened and ball bearings are used throughout the transmission system. It is shown in *Fig. 76*.

The Draw-Bar Pull.— The draw-bar has a pull of 1,000 pounds.

The Power Take Off.— The diameter of the pulley is 8 inches and its face 4 inches; it is driven by a gear from the crankshaft and its normal number of revolutions is 600 per minute when it will deliver 15 horse power. It is fitted with an independent pulley and a pulley clutch of the expanding type.

The Little Bear 4–8 Tractor.— This is a four wheel tractor and appears to be a Ford frame, and power plant set on tractor members, so if you can run a Ford car you can run this tractor without further experience. It is built by the *L. A. Auto Tractor Company,* of Los Angeles, Cal., and it sells for $850.

How it is Made.— The Tractor Gear.— The frame is built up of pressed steel, the front axle is of the knuckle type and a dead rear axle is used. The drive wheels have a diameter of 31 inches and all of the axle bearings are plain. The wheel base is 50 inches and its turning radius is 10 feet.

The length of the tractor is 102 inches, its width is 58 inches and its height is 50 inches. It weighs 1,600 pounds and 75 per cent. of the weight is on the drive wheels. It has the regular motor car type of steering gear and fuel and ignition control.

The Power Plant.— The engine is of the vertical type with four cylinders, has a bore 3¾ by 4 inches, an L head, is cast in block, and its normal speed is 900 r. p. m. It is lubricated by the splash system. The radiator is a tubular one cooled by a belt driven fan and the thermo-siphon cooling system is used. The fuel used is gasoline fed by gravity from the tank to a carburetor which is fitted with a dry air cleaner. The ignition is the low tension magneto system used on all Ford cars. It is shown in *Fig. 77*.

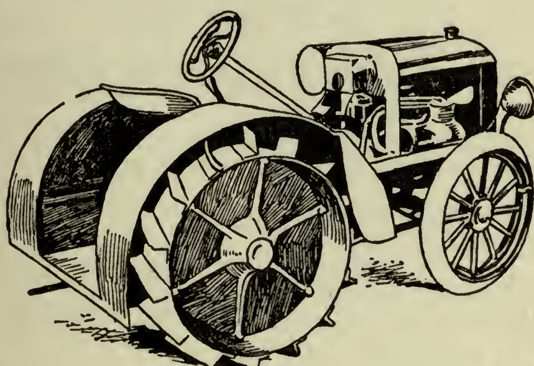


FIG. 77.—THE LITTLE BEAR 4-8 TRACTOR

The Transmission.—This is the Ford planetary gear transmission and it gives two speeds forward and 1 reverse. The differential is bevel geared and enclosed while the final drive is an internal bull-gear and pinion.

The Draw-Bar Pull.—This tractor has a normal draw-bar pull of 800 pounds.

The Power Take Off.—There is none.

CHAPTER VI

TRACTORS FOR AVERAGE FARMS

By the term *average farm* I mean one that is not less than 160 acres or more than 240 acres in extent. The economy of using a tractor on the average farm is now beyond question only you do not want to get the idea that it is going to save you a lot of money as against the use of horses but what it will do is to save you man-power and time.

A two- or three-plow tractor will be large enough for the average farm providing its engine will develop enough power to do all the belt work required of it. There are only some 25 makes of two-plow tractors on the market while there are more than 65 three-plow tractors and a dozen or so that are recommended for either two or three plows. Obviously, it would be impossible within the scope of this book to give detailed specifications of all of them but what I shall do is to describe a few typical tractors and at the end of the chapter you will find a table giving the makers' names and addresses and the names and horsepower of all the two, three and two and three-plow tractors.

TWO PLOW TRACTORS

The Bean Track-Pull, 6–10 Tractor.— This tractor is of the combined wheel and crawler type. It is made by the *Bean Spray Pump Company,* of San Jose, Cal., and the price is $1,445.

How it is Made.— The Traction Gear.— This part of the tractor is formed of a single crawler in front and two non-drive wheels in the rear. The frame is cast in one piece, a dead drive axle is used, the rear axle is cast and has plain bearings and the front suspension is rigid.

The length of the crawler is 36 inches, its width, or tread, 12 inches, and its surface area 432 square inches, while the diameter of the support wheels is 26 inches and the rim face 6 inches. The tractor has a turning radius of 5 feet. Its length over all is 102 inches, its width 60 inches, its height 44 inches and it weighs 3,200 pounds, 85 per cent. of which rests on the crawler. It is shown in *Fig. 78.*

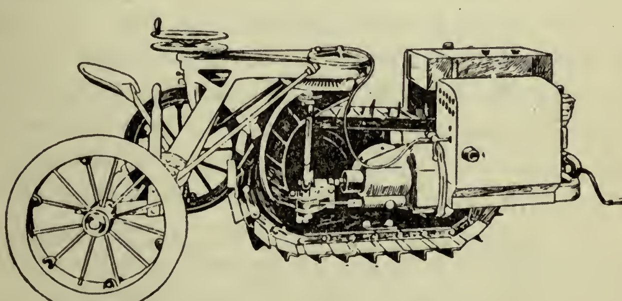


FIG. 78.— BEAN TRACK PULL 6–10 TRACTOR

The Power Plant.— The engine is of the vertical type, has four cylinders cast in block with a 3⅛ by 4½-inch bore and an L head. The normal number of revolutions of the crankshaft is 1,250 per minute, and this is controlled by a centrifugal governor.

It is lubricated by the circulating system and a plunger pump is used for this purpose. A cellular radiator cools the water and this is kept in circulation by a centrifugal pump, while a belt driven fan pulls the air through the radiator. Distillate is the fuel used and this is fed by gravity from the tank to the carburetor. The intake air is heated by the exhaust gases and the carburetor is fitted with a dry air cleaner. The cylinders are fired by a high tension magneto.

The Transmission System.— A cone clutch and a spur-gear transmission with ball bearings is employed; the transmission gives one speed forward and drives the tractor at 2 miles an hour. Since only one crawler is used no differential is needed. The final drive is an internal bull-gear and pinion. The gears are made of carbon steel, are machined and heat-treated.

The Draw-Bar Pull.— The draw-bar is 14 inches from the ground and the tractor has a normal draw-bar pull of 1,125 pounds, which is roughly approximate to 7 h. p. when pulling at a speed of 2½ m. p. h.[1]

[1] The pounds draft a tractor will pull differs with different speeds. Thus a tractor rated at 8 draw-bar horsepower will have a draw-bar pull of 3,000 pounds when pulling 1 mile per hour whereas it will only have a draw-bar pull of 850 pounds when pulling 3½ miles per hour. See Page 271.

The Power Take Off.— The diameter of the belt pulley is 12 inches and the rim face is 4½ inches. As it is driven direct from the crankshaft its normal speed is 1,250 r. p. m.

The Cletrac, 12–20 Tractor.— This tractor is of the true crawler type and it was formerly called *The Cleveland Tractor* hence the name *Cletrac.* It is made by the *Cleveland Tractor Company,* of Cleveland, Ohio, and sells for $1,585.

How it is Made.— The Tractor Gear.— The frame of this tractor is built up of structural steel and the front end is supported by semi-elliptical springs. The front axle is roller bearing, and the rear axle is dead while the drive is roller bearing.

It is 96 inches long, 50 inches wide, 52 inches high and it weighs 3,157 pounds of which, naturally, 100 per cent. rests on the crawlers. The length of the crawlers is 50 inches, the width of the face is 6⅝ inches and the traction area is 600 square inches.

The Power Plant.— The engine is of the vertical type, has four cylinders, the bore of which is 3¾ by 5½ inches. The cylinders have the valves-in-the-head, are cast in block and the normal speed of the engine is 1,200 which is controlled by a centrifugal governor.

A force feed lubricating system is used and the oil is circulated by a gear pump. A tubular radiator holds the cooling water and this is kept in circulation by a gear pump, while a belt driven fan pulls the air through the radiator. Kerosene is the fuel recommended and this is fed from a 12-gallon tank by gravity to the carburetor. Both the air intake and the inlet manifold are heated by the exhaust gases. A high tension magneto is used for the ignition system.

The Transmission System.— The clutch is of the single plate type, the transmission has sliding gears and gives one speed forward and one reverse while the normal speed of the tractor is 2½ m. p. h. The

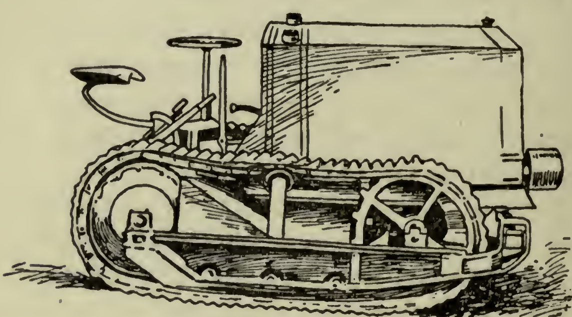


FIG. 79.— THE CLETRAC 12–20 TRACTOR

transmission shafts are ball and roller bearing. The differential, which is used in this crawler tractor, has spur-gears and is ball bearing, while the final drive is an enclosed internal bull-gear and pinion. The gears are of steel, machined and heat treated. It is shown in *Fig. 79.*

The Draw-Bar Pull.— The draw-bar is 12 inches from the ground, and the draw-bar pull of the tractor is 1,500 pounds, or roughly equal to 10 H. P. when plowing at a speed of 2½ m. p. h.

The Power Take Off.— The belt pulley is 8 inches in diameter and 6 inches wide and since it is driven direct from the crankshaft it runs at the normal speed of the engine, namely, 1,200 r. p. m.

The Fordson 12–22 Tractor.— This is a regulation four wheel tractor and is built by *Henry Ford* and *Son, Inc.,* Dearborn, Mich. It sells for $850.

How it is Made.— The Traction Gear.— The frame of this tractor is built up of structural steel.

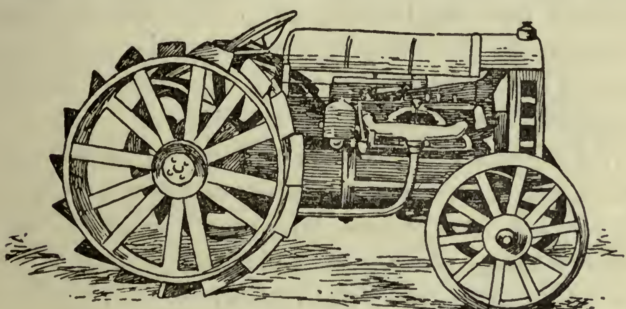


FIG. 80.— THE FORDSON 12–22 TRACTOR

The front axle is of the knuckle type, is drop forged and has ball bearings. The rear axle is live and has roller bearings.

The diameter of the drive wheels is 42 inches and the rim face is 12 inches; the wheel-base is 63 inches and the turning radius of the tractor is 13 feet. It has a length of 102 inches, a width of 60 inches, a height of 55 inches, and it weighs 2,800 pounds, with 63 per cent. of the weight on the drive wheels. See *Fig. 80.*

The Power Plant.— The engine is of the vertical type, has four cylinders with a 4 by 5-inch bore, cast in block and an L valve head, and its normal speed is 1,000 r. p. m. It is lubricated by the splash system and cooled by a radiator, the water being circulated by the thermo-siphon system, with a belt driven fan to pull the air through the radiator. The fuel used is kerosene and this is carried from its tank to the carburetor by gravity, while water is injected into the cylinders with the fuel mixture. The inlet manifold is heated by the exhaust gases and the carburetor has a water air cleaner on its intake pipe. Finally, a magneto is used for the ignition system.

The Transmission System.— The clutch is of the multiple disk type, the transmission gears, which are ball bearing, are enclosed, and have 3 speeds forward and 1 reverse, which give a tractor speed of 1½ to 7 m. p. h. The differential has beveled gears and the final drive, which is enclosed, is of the worm and gear type. The gears are of alloy steel, machined and heat treated.

The Draw-Bar Pull.— The draw-bar can be adjusted from 7 to 15 inches from the ground and the draw-bar pull is 1,800 pounds, or, approximately 12 H. P. when pulling a plow 2½ m. p. h.

The Power Take Off.— The diameter of the belt pulley is whatever you want it to be and its rim face 6½ inches. It is connected to the engine by gears but the speed is the same as the engine speed, to wit, 1,000 r. p. m.

THREE PLOW TRACTORS

The Austin, 15–30 Tractor.— This tractor is of the true crawler type and is manufactured by the *F. C. Austin Company, Inc.,* of Chicago, Ills. Its price is $1,800. This company also makes a 20–40 horse power crawler that pulls from four to six plows and a 75 to 120 horse power crawler that pulls from six to twelve plows.

How it is Made.— The Traction Gear.— The frame

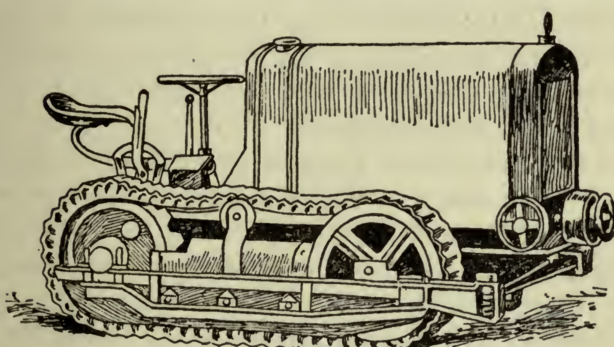


FIG. 81.— THE AUSTIN 15–30 TRACTOR

is built up of structural steel and has a coiled spring suspension in front. The front axle is drop forged and the rear axle is roller bearing. The length of the crawlers are 30 inches, have a face of 8 inches and a traction area of 800 square inches. The turning radius is 4 feet and it is steered by individual clutches. It is shown in *Fig. 81.*

The Power Plant.— The engine is of the vertical type, has four cylinders with a 4 by 5-inch bore, an L valve head and it has a normal speed of 1,000 r. p. m., which is controlled by a centrifugal governor.

It is lubricated by the force feed system, a plunger pump being used to keep the oil in circulation. The radiator is of the cellular type, the water is kept in circulation by a centrifugal pump, and a belt driven fan is used back of the radiator. Kerosene is the fuel recommended and this is contained in a 12-gallon tank. It is fed to the carburetor by gravity and the carburetor is fitted with a dry air cleaner. A high tension magneto is used for the ignition system and the magneto is equipped with an impulse starter. *Fig. 81* is a picture of the tractor.

The Transmission System.— The clutch is of the single disk type and is ball bearing. The transmission is of the sliding gear type, has 2 speeds forward and 1 reverse which gives a range of tractor speeds of from 2⅓ to 3⅓ m. p. h. The differential, which is enclosed, is of the spur gear type and is roller bearing, while the final drive is by an enclosed chain. The gears are of carbon steel, machined and heat treated.

The Draw-Bar Pull.— The draw-bar, which is swivelled, is 17 inches from the ground and the tractor has a normal draw-bar pull of 2,000 pounds, which is equivalent to about 14 H. P. when pulling 2½ m. p. h.

The Power Take Off.—The diameter of the pulley is 8 inches and it has a face of 6 inches; it is geared to the crankshaft of the engine and its normal speed is 1,000 r. p. m.

The Andrews, 12–25 Tractor.— This is a good example of a cheap two- or three-plow tractor. It is made by the *Andrews Tractor Company,* of Minneapolis, Minn., and it sells for $695.

How it is Made.— The Tractor Gear.— The frame is built up of structural steel and the front suspension is fitted with coiled springs. The front axle is drop forged and is of the knuckle type, while the rear axle is dead.

It has three traction members, the drive member being a steel drum having a diameter of 48 inches and a rim face of 30 inches. The front wheels are 36 inches in diameter and have a face of 8 inches. Roller bearings are used on both the front and drive wheels. The tractor has a wheel base of 110 inches and its turning radius is 24 feet. It has a length of 180 inches, a width of 88 inches, a height of 56 inches and a weight of 4,400 pounds. It is shown in *Fig. 82.*

The Power Plant.— The engine is of the horizontal, opposed cylinder type; it has four cylinders, cast singly, with a 4- by 5-inch bore; the normal speed is 1,000 r. p. m., and this is controlled by a centrifugal governor.

It is lubricated by the force feed system, has no radiator but is air cooled by a belt driven fan. Gasoline is the fuel used and this is fed from a 20-gallon tank by gravity to the carburetor. The ignition system includes a high tension magneto.

The Transmission System.— No clutch is used as

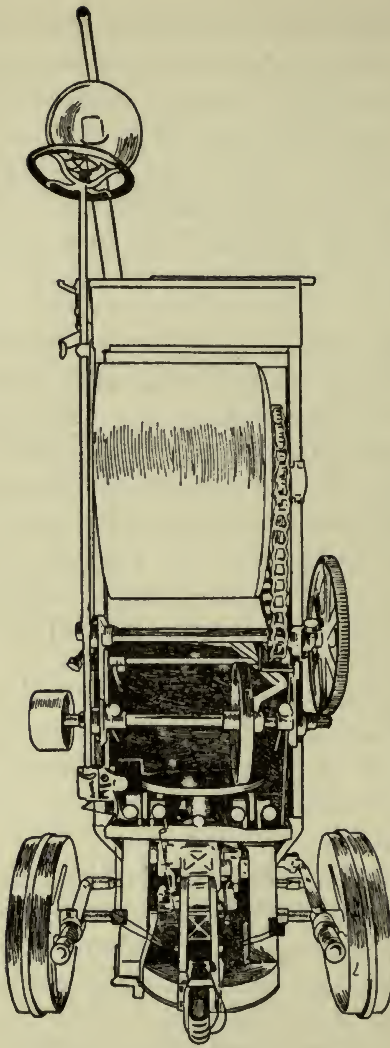


Fig. 82.— Top View of the Andrews 12–25 Drum Tractor (Showing Friction Drive)

the transmission consists of a friction drive which gives a tractor speed of from 1 to 3 m. p. h., either forward or reverse. Since a drum is used as the drive traction member which is the equivalent of a single drive wheel, no differential is needed. The final drive is the chain and sprocket and this is open. The gears are of cast steel, machined and case hardened and all the bearings are plain.

The Draw-Bar Pull.— The draw-bar, which is swivelled, is 16 inches from the ground and the normal draw-bar pull is 1,900 pounds, or, a little over 12 H. P. when pulling 2½ m. p. h.

The Power Take Off.— The belt pulley has a diameter of 12 inches and a 7-inch face and as it is directly connected with the crankshaft its normal speed is 1,000 revolutions per minute. It has an independent clutch and a pulley brake.

The E. B., 12–20; Model AA Tractor.— This is an excellent model of a higher priced tractor of about the same capacity as the one just described only it has the *Society of Automotive Engineers* rating and this is only 80 per cent. of the actual power the tractor develops. It costs $1,500.

How it is Made.— The Tractor Gear.— The frame of this tractor is built up of structural steel. Its drive axle is live and roller bearing and the front axle is drop forged, has plain bearings and is of the knuckle type.

The diameter of the drive wheels, which are in the rear, is 45 inches with a rim face of 12 inches while the front wheels are 36 inches in diameter and have a 6-inch face. The wheel base is 87 inches and the tractor has a turning radius of 25 feet. It has a length of 121¾ inches, a width of 55 inches, a height of 75¼ inches and it weighs 4,355 pounds, of which 66 per cent. is on the drive wheels. Its clearance is 14 inches. It is shown in *Fig. 83*.

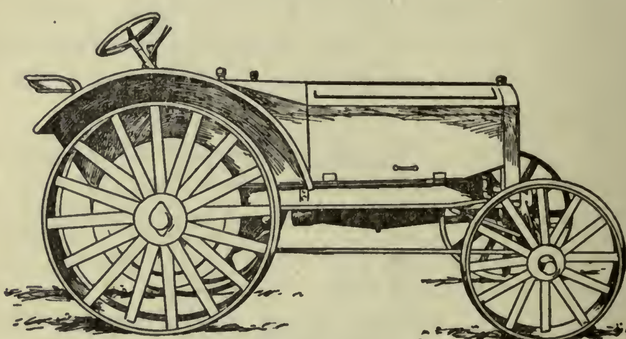


FIG. 83.— THE E.-B. 12–20 TRACTOR

The Power Plant.— The engine is of the vertical type, with an L valve head and the cylinders, which are cast in pairs, have a 4¾- by 5-inch bore. The engine has a normal speed of 900 r. p. m. It is lubricated by the circulating splash system and the oil is kept in circulation by a plunger pump. The engine is water cooled, has a cellular radiator and the water is circulated by a centrifugal pump, while the fan is gear-driven.

Kerosene is the fuel recommended and this is fed by gravity to the carburetor; the latter is fitted with a dry air cleaner and the exhaust gases heat both the air intake and the manifold; water is injected into the cylinders along with the fuel mixture. Finally a magneto supplies the high tension current for the ignition system.

The Transmission System.— This system has a cone clutch and a sliding gear transmission fitted with roller bearings, it has 2 speeds forward and 1 reverse and this gives a tractor speed of 1.81 and 2.33 m. p. h., respectively. The differential has beveled gears, is enclosed and has roller bearings, while the final drive is an internal bull-gear and pinion. All of the gears are made of carbon steel, machined and are heat treated.

The Draw-Bar Pull.— The draw-bar is pivoted and adjustable from 14 to 16 inches from the ground. The normal draw-bar pull is 2,500 pounds which is, about equal to 16 H. P. when pulling 2½ m. p. h.

The Power Take Off.— The belt pulley has a diameter of 12 inches and a width of 6⅜ inches, is gear driven from the crankshaft and is fitted with roller bearings. It also has an independent clutch of the contracting band type.

OTHER TWO AND THREE PLOW TRACTORS

There are many other two and three plow tractors to choose from and these are given in the following tables:

OTHER AVERAGE FARM TRACTORS

Automotive Corporation, Toledo, Ohio..	*12–24*	*Automotive*
Avery Company, Peoria, Ills............	*5–10*	*Model B*
Blumberg Motor Mfg. Co., Orange, Tex.	*12–24*	*Steady Pull*
Blumberg Motor Mfg. Co., Orange, Tex.	*7–18*	*Steady Pull*
J. P. Case Threshing Machine Co., Racine, Wis..........................	*10–18*	*Case*
Cleveland Tractor Co., Cleveland, Ohio..	*12–20*	*Cletrac*
Dausch Mfg. Co., Sandusky, Ohio.......	*10–20*	*Sandusky J.*
Essex Tractor Co., Ltd., Essex, Ont.....	*12–20*	*Essex*
Fageol Motors Co., Oakland, Cal.......	*9–12*	*Fageol*
General Tractors, Inc., Chicago, Ills.....	*9–16*	*Monarch*
Gilson Mfg. Co., Lt., Guelph, Ont.......	*11–20*	*Dixie Ace*
Hackney Mfg. Co., St. Paul, ,Minn......	*12–20*	*Corn Tractor*
International Harvester Co., of Am., Chicago, Ill..........................	*8–16*	*International*
Kansas Hay Press and Tractor Co., Kansas City, Mo.....................	*10–18*	*Prairie Dog*
Kardell Tractor and Truck Co., St. Louis, Mo..........................	*10–20*	*Kardell Utility*
Homer Laughlin Engineers Corporation, Los Angeles, Cal.....................	*10–20*	*Laughlin*
Moline Plow Co., Moline, Ills...........	*9–18*	*Moline Universal*
Ohio Mfg. Co., Upper Sandusky, Ohio..	*9–18*	*Whitney*
R. and P. Tractor Co., Alma, Mich......	*12–20*	*R. & P.*
Reliable Tractor Engine Co., Portsmouth, Ohio.........................	*10–20*	*Reliable*
Rock Island Plow Co., Rock Island, Ills.	*9–16*	*Heides "D"*
Russell and Co., Massillon, Ohio........	*12–24*	*Russell Jr.*
Sampson Tractor Co., Janesville, Wis...		*Sampson M*
Scientific Farming Machinery Co., Minneapolis, Minn..................	*10–20*	*Mark VI Princess Pat*
Shelby Tractor and Truck Co., Shelby, Ohio	*9–18*	*Shelby Model*
H. A. Wetmore, Sioux City, Iowa......	*12–25*	*Wetmore*

TWO OR THREE PLOW TRACTORS

Allis-Chalmers Mfg. Co., Milwaukee, Wis.	*10–18*	*Allis-Chalmers*
Andrews Tractor Co., Minneapolis, Minn.	*12–25*	*Andrews*
Avery Co., Peoria, Ills..................	*8–16*	*Avery*
Bean Spray Pump Co., San Jose, Cal....	*8–16*	*Bean Tract Pull*

Two or Three Plow Tractors (*Con.*)

Bull Tractor and Madison Motors Corp., Anderson, Ind.	*12–24*	*Big Bull*
Chase Tractors Corporation, Ltd., Toronto, Can.	*12–25*	*Chase*
Dayton-Dowd Co., Quincy, Ills.	*12–18*	*Leader B*
Elgin Tractor Corporation, Piqua, Ohio	*10–20*	*Elgin*
Franklin Tractor Co., Franklin, Ohio	*15–30*	*Centipede*
General Ordnance Co., Inc., New York, N. Y.	*12–22*	*GO-F*
Ohio General Tractor Co., Cleveland, Ohio	*15–30*	*Ohio General*
Russell and Co., Massillon, Ohio	*15–30*	*Little Boss*
Stirling Machine and Stamping Co., Wellington, Ohio	*12–22*	*Wellington F*
Wichita Tractor Co., Wichita, Kas.	*9–18*	*Mid-West*

Three Plow Tractors

Advance-Rumely Thresher Co., Inc., La Porte, Ind.	*12–20*	*Oil Pull*
American Tractor Corp., Peoria, Ills.	*12–25*	*Yankee*
Appleton Mfg. Co., Batavia, Ills.	*12–20*	*Appleton*
F. C. Austin Co., Inc., Chicago, Ills.	*15–30*	*Austin*
Bates Tractor Co., Lansing, Mich.	*15–25*	*Bates All Steel Oil*
J. I. Case Plow Works Co., Racine, Wis.	*15–25*	*Wallis*
J. I. Case Threshing Machine Co., Racine, Wis.	*10–20*	*Case*
Champion Tractor Co., Argo, Ills.	*17½x32*	*Champion*
C. O. D. Tractor Co., Minneapolis, Minn.	*13–25*	*C. O. D. Model B*
Coleman Tractor Co., Kansas City, Mo.	*16–30*	*Coleman*
Comet Automobile Co., Decatur, Ills.	*15–30*	*Comet*
Craig Tractor Co., Cleveland, Ohio	*15–25*	*Craig*
Dart Truck and Tractor Corp., Waterloo, Iowa		*Blue J.*
Deere and Co., Moline, Ills.	*12–25*	*Waterloo Boy*
G. I. Dill Tractor Mfg. Co., Harrisburg, Ark.	*26*	*Dill Harvesting*
G. I. Dill Tractor Mfg. Co., Harrisburg, Ark.	*26*	*Short Dill*
C. H. A. Dissinger and Bro., Co., Wrightsville, Pa.	*10–20*	*Capital*
Eagle Manufacturing Co., Appleton, Wis.	*12–22*	*Eagle*
Electric Wheel Co., Quincy, Ills.	*14–28*	*Allwork*

THREE PLOW TRACTORS (*Con.*)

Emerson-Brantingham Implement Co., Rockford, Ills.	*12–20*	*E. B. Model "AA"*
Essex Tractor Co., Ltd., Essex, Ont.	*15–30*	*Essex*
Frick Co., Waynesboro, Pa.	*12–24*	*Frick*
General Ordnance Co., Inc., New York, N. Y.	*14–28*	*GO-G*
General Tractors, Inc., Chicago, Ills.	*12–20*	*Monarch*
Gould, Shapley and Muir Co., Ltd., Brantford, Ont.	*14–28*	*Beaver*
Hackney Mfg. Co., St. Paul, Minn.	*15–30*	*No. 5 Auto-Plow*
Hart-Parr Co., Charles City, Iowa	*30*	*Hart-Parr 30*
Hession Tiller and Tractor Corp., Buffalo, N. Y.	*12–24*	*Wheat*
Hicks Tractor Co., Milwaukee, Wis.	*12–25*	*Hicks*
Huber Mfg. Co., Marion, Ohio	*12–25*	*Huber Light Four*
Hunter Tractor Co., Los Angeles, Cal.	*15–25*	*Hunter*
International Harvester Co., of Om., Chicago, Ills.	*10–20*	*Titan*
Keck-Gonnerman Co., Mt. Vernon, Ind.	*12–24*	*Keck-Gonnerman*
Kinnard and Sons Mfg. Co., Minneapolis, Minn.	*14–24*	*Flour City Jr.*
La Crosse Tractor Co., La Crosse, Wis.	*12–24*	*Model F*
Leader Tractor Mfg. Co., Des Moines, Iowa	*12–25*	*Rex*
Leonard Tractor Co., Jackson, Mich.	*20–30*	*Leonard*
Liberty Tractor Co., Dubuque, Iowa	*16–32*	*Klumb F*
Macdonald Thresher Co., Ltd., Stratford, Ont.	*12–24*	*Macdonald*
Maxim Corporation, New York, N. Y.	*12–24*	*Maxim*
Minneapolis Steel and Machinery Co., Minneapolis, Minn.	*12–20*	*Twin City 12*
Minneapolis Threshing Machine Co., Hopkins, Minn.	*12–25*	*Minneapolis*
Nelson Corporation, Boston, Mass.	*15–24*	*Nelson*
Nilson Tractor Co., Minneapolis, Minn.	*16–25*	*Nilson Jr.*
Oliver Tractor Co., Knoxville, Tenn.	*15–30*	*Oliver*
Parrett Tractor Co., Chicago Heights, Ills.	*12–25*	*Parrett*
Peoria Tractor Corp., Peoria, Ills.	*12–25*	*Peoria J*
Pope Mfg. Co., Watertown, So. Dakota.	*17–27*	*Dakota*
Port Huron Engine and Thresher Co., Port Huron, Mich.	*12–25*	*Port Huron*
Reed Foundry and Machine Co., Kalamazoo, Mich.	*12–25*	*Reed*

Three Plow Tractors (*Con.*)

Rock Island Plow Co., Rock Island, Ills.	*12–20*	*Heider "C"*
Royer Ensilage Harvester Co., Wichita, Kas.	*12–25*	*Royer*
Shelby Tractor and Truck Co., Shelby, Ohio	*15–30*	*Shelby D*
Short Turn Tractor Co., Moorehead, Minn.	*28–40*	*Short Turn*
Square Turn Tractor Co., Norfolk, Neb.	*18–35*	*Square Turn*
Sterling Machine and Stamping Co., Wellington, Ohio	*20–40*	*Wellington*
Sutherland Machinery Co., Minneapolis, Minn.	*16–28*	*New Age*
Trenam Tractor Co., Inc., Stevens Point, Wis.	*12–24*	*Trenam*
Turner Mfg. Co., Port Washington, Wis.	*14–25*	*Turner-Simplicity*
U. S. Tractor Co., Minneapolis, Minn.	*15–30*	*U. S.*
U. S. Tractor and Machine Co., Wenasha, Wis.	*20–30*	*Uncle Sam*
Velie Motors Corp., Moline, Ills.	*12–24*	*Biltwell*
Wabash Tractor Co., Wabash, Ind.	*25*	*Motox*
Wisconsin Farm Tractor Co., Lank City, Wis.	*16–32*	*Wisconsin*
Wolverine Tractor Co., Detroit, Mich.	*15–30*	*Wolverine*

CHAPTER VII

TRACTORS FOR BIG FARMS

THE big farm has been the graveyard not only for many a tractor but for many a tractor manufacturing company as well. Phoenix-like, however, other tractor companies have risen out of the ashes and have built their tractors upon the experiences of those that have gone before so that it is now just as safe an investment to buy a tractor for a big farm as it is to buy one for the average sized farm — that is, if you buy understandingly.

The following specifications include, practically, all the companies making tractors that will pull from four to twelve plows. There are several factors that have a definite bearing on the economical value of using a large tractor as against two or more smaller tractors which will pull the same number of plow bottoms and you take up this matter with the engineers of the company whose tractor or tractors you are buying.

The tractors which I have described in this chapter show the general construction of the latest and most powerful types and from the accompanying text you will be able to broadly compare them.

The Oil-Pull Tractors.— The *Advance-Rumely Thresher Company, Inc.,* of La Porte, Ind., make a line of big farm tractors that include a 16–30, pulling four plows,[1] at a price of $2,400; a 20–40, pulling five or six plows, at a price of $3,300, and a 30–60, pulling eight or ten plows, at a price of $4,700.

The Traction Members.— All of these tractors have four wheels with the drive wheels in the rear.

The Power Plant.— All of them, also, are powered with *horizontal* opposed *two* cylinder engines, the

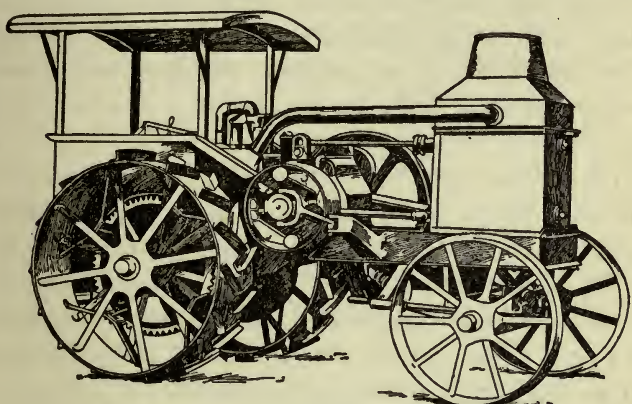


FIG. 84.— THE OIL-PULL TRACTOR

normal speeds of which are 530 r. p. m., for the 16–30; 450 r. p. m., for the 20–40, and 375 r. p. m., for the 30–60. All sizes are lubricated with the force feed system. *Oil* is used as the cooling liquid and it is circulated through the radiator by a centrifugal pump while the air is pulled through the radiator by the exhaust of the engine. The carburetor uses any kind

[1] All plows unless otherwise specified are 14 inch.

of oil fuel and the ignition system includes a high tension magneto with an impulse starter.

The Transmission System.— All sizes have an expanding shoe clutch and a sliding gear transmission that has 2 speeds forward and 1 reverse, and this gives a tractor speed of 2.1 to 3 miles per hour for the 16–30; 2 to 3½ m. p. h., for the 20–40 and 1.9 m. p. h., for the 30–60. All sizes have bevel gear differentials, the smallest size being open and the two larger sizes being enclosed and all are roller bearing. The final drive is an external bull-gear and pinion and this is open. The 30–60 tractor is shown in *Fig. 84*.

The Draw-Bar Pull.— In the 16–30 the normal draw-bar pull is 2,850 pounds; in the 20–40 it is 3,750 pounds, and in the 30–60 it is 5,900 pounds.

The Power Take Off.— The belt pulley runs at the same speed of the engine and, hence, the normal speed is 530 r. p. m., for the 16–30; 450 r. p. m., for the 20–40, and 375 r. p. m., for the 30–60.

The Aultman–Taylor Tractors.— A line of three big farm tractors is made by the *Aultman-Taylor Machinery Company,* of Mansfield, Ohio. These embrace a 15–30 for three or four plows that sells for $2,400; a 22–45 for four to six plows that sells for $4,100; and a 30–60 for eight to 12 plows that sells for $5,200.

The Traction Members.— All three tractors have four wheels with the drive wheels in the rear.

The Power Plant.— The 15–30 has a *four* cylinder *vertical* engine whose normal speed is 900 r. p. m., the 22–45 has a *four* cylinder, *vertical,* valve-in-the-head engine whose normal speed is 600 r. p. m., and the 30–60 has a *four* cylinder, *horizontal* engine, whose normal speed is 500 r. p. m.

The lubrication in these tractors is by individual pump positive feed; the cooling system includes a tubular radiator, a centrifugal pump for circulating the water and a belt driven fan. Either gasoline or kerosene is used and is fed to the carburetor by gravity while the ignition system includes a true high tension magneto.

The Transmission System.— All of the above sizes are fitted with the expanding shoe clutch and a sliding gear transmission. The 15–30 and the 30–60 have 1 speed forward and 1 reverse, and the 22–45 has two speeds forward and one reverse, while the tractor speed of all of them is 2.2 m. p. h. The differential of the 15–30 is of the spur-gear type and is enclosed while that in the two largest sizes is of the bevel gear type and open. The final drive in all of them is an open external bull-gear and pinion. One of these tractors is shown in *Fig. 85*.

The Draw-Bar Pull.— The normal draw-bar pull of the 15–30 is 2,800 pounds; of the 22–45 is 4,800 pounds, and of the 30–60 tractor is 8,000 pounds.

The Power Take Off.— The normal speed of the belt pulley of all three sizes is the same as the normal speed of the engine which is given above.

The Avery Tractors.— The *Avery Company,* of Peoria, Ills., makes a line of three tractors for big farms. These are an 18–36, that pulls *four* or *five* plows, the price of which is $2,250; a 25–50 that pulls *five* or *six* plows, the price of which is $3,100, and a

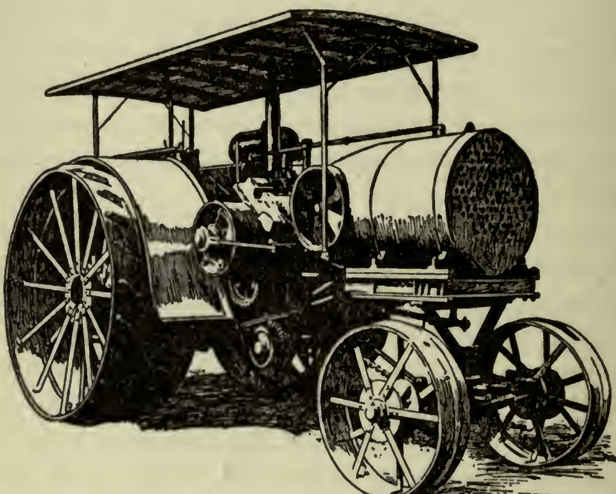


FIG. 85.— THE AULTMAN-TAYLOR TRACTOR

40–80, that pulls *eight* or *ten* plows, the price of which is $3,950.

The Traction Members.— All of the above sizes have four wheels with the drive wheels in the rear.

The Power Plant.— The engines in all of them are of the *horizontal* opposed cylinder type and all are lubricated by the circulating system. Likewise, all have a tubular radiator through which the air is forced by the exhaust of the engine. Any kind of liquid fuel can be used and this is fed by gravity to the carburetor. Finally, all sizes have a magneto ignition system.

The Transmission System.— The expanding shoe clutch is common to all three sizes, as is the sliding gear transmission which is open; all of the sizes have two speeds forward and one reverse and this gives in the 18–36 and the 25–50 a range of tractor speeds of 2 to 3 m. p. h., and in the 40–80, of 1½ to 4½ m. p. h. The differential in all of them is of the bevel gear type and open. The final drive is an open, external bull-gear and pinion and the bearings in the drive axle are plain. A large Avery tractor is shown in *Fig. 86.*

The Draw-Bar Pull.— The normal draw-bar of the 18–36 is 2,700 pounds; of the 25–50 is 3,750 pounds, and of the 40–80 is 6,000 pounds.

The Power Take Off.— In all three sizes the normal speed of the belt pulley is the same as the normal speed of the engine which runs it and this is given above.

The Bates Steel Mule.— This 15–22 tractor is made by the *Bates Machine and Traction Company,* of Joliet, Ills., and pulls *three* or *four* 14 inch plows. Its price is $2,200.

The Traction Members.— The *Steel Mule* is a combined wheel and crawler tractor having two wheels in front and two crawlers at the rear.

The Power Plant.— The engine is of the *vertical* type, has 4 cylinders and runs at a normal speed of 900 r. p. m. It is lubricated by the circulating pump

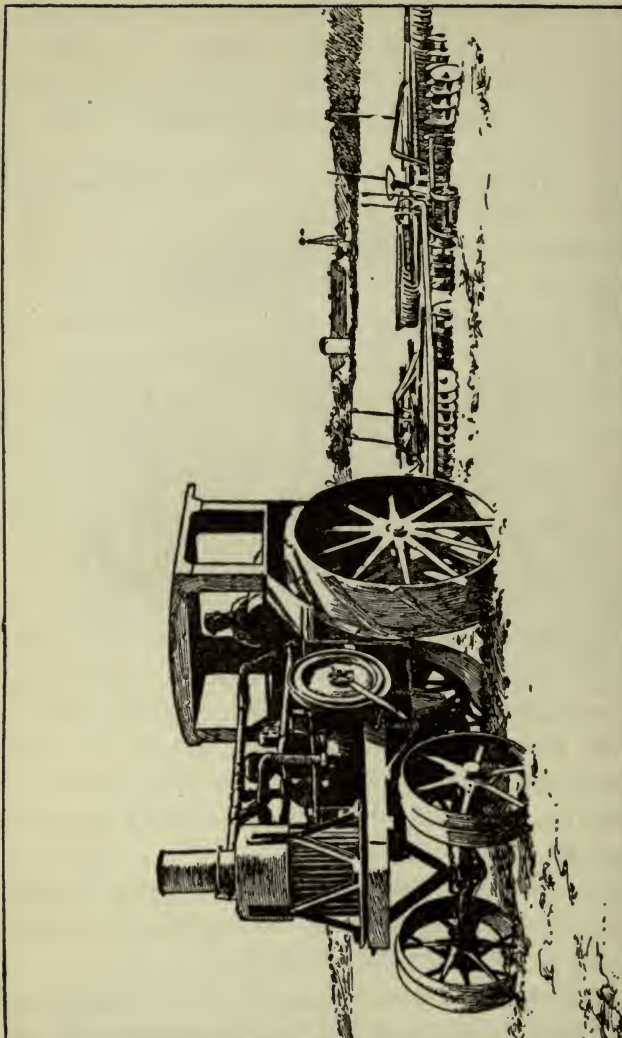


FIG. 86.— THE AVERY TRACTOR

system and is cooled by a centrifugal pump and belt driven fan. It uses any kind of liquid fuel which is fed to the carburetor by gravity while a high tension magneto is employed to fire the cylinders.

The Transmission System.— The clutch is of the single disk type and is enclosed. The transmission, which is roller bearing, is of the sliding gear type with two speeds forward and one reverse which give

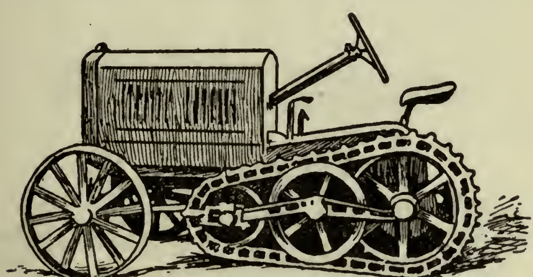


FIG. 87.— THE BATES STEEL MULE

a range of tractor speeds of from 2.4 to 3.4 m. p. h. An enclosed bevel gear differential is used and the final drive is an enclosed spur gear and pinion. It is shown in *Fig. 87*.

The Draw-Bar Pull.— The normal draw-bar pull of this tractor is 2,250 pounds.

The Power Take Off.— The belt pulley has a speed of 775 r. p. m., when the engine is running at its normal speed.

The Tracklayer Tractors.— There are three sizes of big tracklayer tractors and these are made by the

C. L. Best Gas Traction Company, of San Leandro, Cal. The first two sizes are of the true crawler type and the largest size is of the combined wheel and crawler type. The 22–40 will pull from four to six plows and costs $4,100; the 35–60 will pull from six to eight plows and costs $4,900, and the 38–75 will pull from eight to twelve plows and costs $5,850.

The Traction Members.— The first two sizes, namely, the 22–40 and the 35–60 are of the true crawler

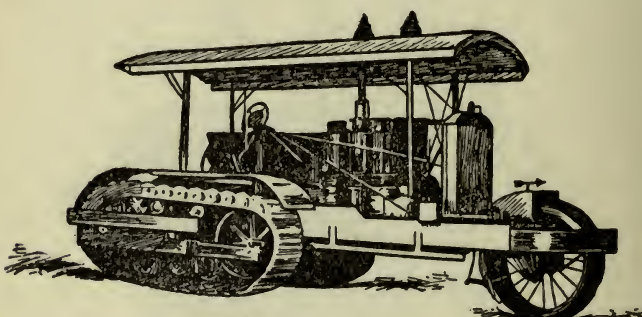


FIG. 88.— THE TRACKLAYER TRACTOR

type and hence have a crawler on either side. The 38–75 is a combined wheel and crawler tractor, having one wheel in front and a pair of crawlers in the rear.

The Power Plant.— The engines in all of them are of the vertical, four cylinder type. In the 22–40 the normal speed of the engine is 600 r. p. m.; in the 35–60 the normal speed is 650 r. p. m., and in the 38–75 it is 435 r. p. m.

The lubrication system used in the 22–40 is the circulating splash, in the 35–60 the force feed system with a rotary pump is used, while in the 38–75 the force feed and splash system is employed. The cooling system in all of the sizes includes a tubular radiator and a fan but the 22–40 has a gear pump, the 35–60 has a centrifugal pump and the 38–75 has a rotary pump.

The fuel used for the 22–40 is gasoline fed by gravity, for the 35–60, distillate fed by the vacuum system and for the 38–75 also distillate, which is fed by gravity. All of the sizes have the magneto ignition system with an impulse starter. A *Tracklayer* is shown in *Fig. 88.*

The Draw-Bar Pull.— The normal draw-bar pull of the 22–40 is 3,200 pounds; of the 35–60 is 5,500 pounds, and of the 38–75 is 6,600 pounds.

The Power Take Off.— The r. p. m., of the belt pulley of the 22–40 is the normal r. p. m. of the engine, namely, 600 per minute; of the 35–60 at normal engine speed is 650 r. p. m., and of the 38–75 it is 550 r. p. m.

The Case Tractors.— These big farm tractors are made by the *J. I. Case Threshing Machine Company, Inc.,* of Racine, Wis. Here are two sizes, namely, the 15–27, that pulls three or four plows and costs $1,600, and the 20–40 that pulls five or six plows and costs $3,000.

The Traction Members.— Both sizes are of the four-wheel type with the drive wheels at the rear.

The Power Plant.— The engine in the 15–27 is of the *vertical* type and has *four* cylinders, while its normal speed is 900 r. p. m. The engine in the 20–40 is of the *horizontal* opposed cylinder type and its normal speed is 475 r. p. m.

The 15–27 engine is lubricated by the circulating splash system and the 20–40 by the individual pump positive feed system. Again, the smaller engine is cooled by a tubular radiator, a centrifugal pump and a fan, while the larger engine is cooled by the thermo-siphon system, and employs a tubular radiator and a fan.

Further, the smaller size uses kerosene or distillate while the larger size uses any kind of liquid fuel and both employ the gravity feed system. Finally, both sizes are provided with a magneto having an impulse starter for the ignition. *Fig. 89* shows a *Case* tractor.

The Transmission System.— The clutch in both sizes is of the expanding shoe type and the transmission is of the sliding gear type with two speeds forward and one reverse; in the 15–27 the tractor speed is from 2¼ to 3½ m. p. h. The differential in the smaller size is open and in the larger size it is enclosed. The final drive in both sizes is an external bull-gear and pinion.

The Draw-Bar Pull.— The normal draw-bar pull of the 12–27 is 2,500 pounds and of the 20–40 is 3,740 pounds.

The Power Take Off.— In both sizes the normal belt power speed is the same as the normal engine

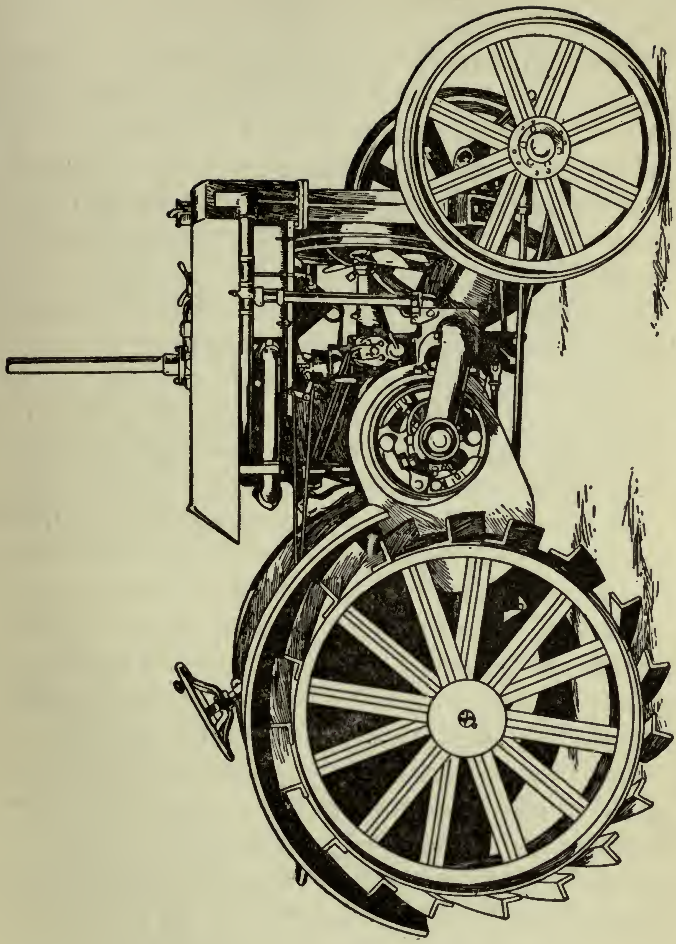


Fig. 89.— The Case Tractor

speed, to wit, 900 r. p. m., and 475 r. p. m., respectively.

The E. B. Tractors.— The *Emerson-Brantingham Company,* of Rockford, Ills., makes two big farm tractors. The 20–35 pulls five plows and costs $2,000, and the 40–65 pulls *eight* to *ten* plows and costs $4,250.

The Tractor Members.— The tractors of both sizes are of the four-wheel type with the drive wheels at the rear.

The Power Plant.— The engines in both sizes are of the *vertical* type, have *four* cylinders and run at a normal speed of 700 r. p. m., and 500 r. p. m., respectively. The 20–35 engine is lubricated by the splash system and the 40–65 engine is lubricated by the individual pump positive feed system.

The cooling system of the 20–35 includes a cellular radiator, a centrifugal pump and a fan, while that of the 40–65 has a cellular radiator, a plunger pump and a fan. The fuel used in either engine is kerosene but in the 20–35 it is fed to the carburetor by gravity while in the 40–65 it is fed by compressed air. The magneto ignition system is used in both sizes.

The Transmission System.— A cone clutch is employed in both sized tractors as is also a sliding gear transmission. In the 20–35 the latter has two speeds forward and one reverse and this gives the tractor a range of speeds of 1.71 to 2.26 m. p. h., while in the 40–65 it has one speed forward and one reverse, which gives a traction speed of 2 m. p. h. The differential of both transmission systems is open. The final drive is by an external bull-gear and pinion. A big *E. B.* tractor is shown in *Fig 90.*

The Draw-Bar Pull.— The normal draw-bar pull of the 20–35 is 3,600 pounds and that of the 40–65 is 10,000 pounds.

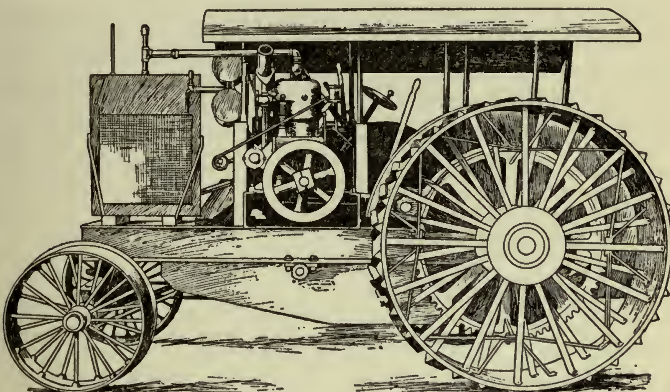


FIG. 90.— THE E.-B. 40–65 TRACTOR

The Power Take Off.— The normal speed of the belt pulley of the 20–35 is 595 r. p. m., while that of the 40–65 is 500 r. p. m.

The Caterpillar Tractors.— This line of four big crawlers is built by the *Holt Manufacturing Company*, of Peoria, Ills. The two smaller ones are of the true crawler type and the two larger sizes are of the combined wheel and crawler type. The 25–45 will pull from four to six plows and the 40–60 will pull from six to eight plows.

The Power Plant.— The engines in all of the above tractors are of the vertical type; in the first three sizes they have four cylinders, and the last one has six cylinders. In the 25–45 the normal engine speed is 600 r. p. m., in the 40–60 it is 650 r. p. m., in the 50–75 it is 900 r. p. m., and in the 70–120 it is 550 r. p. m.

The lubrication in all of them is by the individual pump positive feed system and the cooling system includes a tubular radiator, a centrifugal pump and a fan. The fuel used in the 25–45 is gasoline fed by the vacuum system; in the 40–60 it is gasoline or kerosene, likewise, fed by the vacuum system; in the 50–75 either gasoline or kerosene is used and this is fed by gravity, and in the 70–120 gasoline is recommended and it is fed by the vacuum system. All sizes are equipped with the magneto and this is fitted with an impulse starter. A top view of a 10-ton Caterpillar is shown in *Fig 13, Chapter II.*

The Transmission System.— All of the *Caterpillar* tractors have multiple disk clutches. The 25–45 size has a spur-gear transmission with two speeds forward and one reverse giving a range of tractor speeds of from 1½ to 3½ m. p. h.

The 40–60 has a sliding gear transmission of three speeds forward and one reverse, which give a range of tractor speeds of from 1.4 to 3.9 m. p. h.; the 50–75 has a planetary gear transmission with one speed forward and one reverse, which give a range of tractor speeds of from 2 to 5 m. p. h., and, finally, the 70–120 has a sliding gear transmission with two speeds forward and one reverse which give a range of tractor speeds of from 1½ to 3 m. p. h.

The 40–60 size has a differential but the other three sizes have none. The final drive of the 25–45 is an internal gear and pinion; that of the others is a chain drive.

The Draw-Bar Pull.— The normal draw-bar pull of the 25 to 45 is 4,500 pounds; that of the 40 to 60 is 6,000 pounds; that of the 50 to 75 is 8,500 pounds, and that of the 70–120 is 10,600 pounds.

The Power Take Off.— The speed of the belt pulley at normal engine speed of the 25–45 is 865 r. p. m.; that of the 40–60 is 710 r. p. m.; that of the 50–75 is 900 r. p. m., and that of the 70–120 is 460 r. p. m.

The International 15–30 Tractor.— This big farm tractor is built by the *International Harvester Company of America,* at Chicago, Ills. It will pull four plows and it costs $4,000.

The Traction Members.— This tractor is of the four-wheel type with the drive wheels in the rear.

The Power Plant.— The engine is of the *horizontal, four* cylinder type and has a normal speed of 575 revolutions per minute. It is lubricated by the individual pump positive feed system and is cooled by a tubular radiator, a rotary pump and a fan. The fuel used is kerosene and this is fed by a pump to the carburetor. A magneto is the source of high tension current that fires the fuel charge.

The Transmission System.— The clutch is of the single disk type and the transmission, which is of the sliding gear type has two speeds forward and one reverse and gives a tractor speed of 1.8 to 2.4 m. p. h. The differential is enclosed and the final drive is by a chain and sprocket and this is also enclosed. A picture of the *International* is shown in *Fig. 91*.

The Draw-Bar Pull.— The normal draw-bar pull is 2,350 pounds.

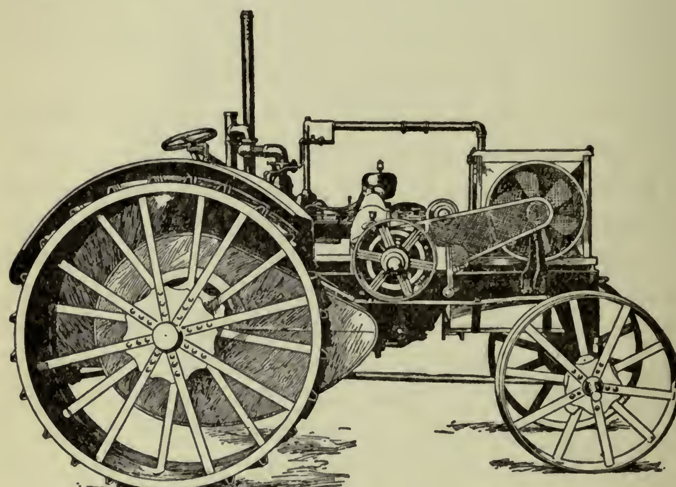


FIG. 91.— THE INTERNATIONAL 15–30 TRACTOR

The Power Take Off.— The belt pulley has a speed of 575 r. p. m., when the engine is running at its normal speed.

The Twin City Tractors.— This is a line of big farm tractors that is built by the *Minneapolis Steel and Machinery Company,* of Minneapolis, Minn. There are four of these tractors, namely, the 16–30, which pulls *four* plows and which sells for $3,500; the 25–45, which pulls *six* plows and sells for $4,200; the 40–65 which pulls *eight* plows and sells for $5,000, and the 60–90, which pulls *twelve* plows and sells for $6,000.

The Traction Members.— All of the above tractors are of the four-wheel type with the drive wheels in the rear.

The Power Plant.— The engines in all of these tractors are of the *vertical* type and the first three sizes have *four* cylinders while the last and largest has a *six* cylinder engine. The 16–30 has a normal engine speed of 650 r. p. m.; the 25–40 has a speed of 600 r. p. m.; the 40–65 and the 60–90 have a speed of 535 r. p. m.

The lubrication of them all is by the individual pump positive feed system, and the cooling system includes a tubular radiator, a centrifugal pump and a fan. The fuel used in all of the sizes is gasoline or kerosene and it is fed in the 16–30 by the vacuum system; and in the others by the compressed air system. All of the engines have the magneto system of ignition and the magneto is fitted with an impulse starter.

The Transmission System.— The contracting band clutch is used in all sizes of these tractors as well as a sliding gear transmission. In the first two sizes it gives two speeds forward and one reverse and in the last two sizes it gives one speed forward and one reverse. In the 16–30 the range of tractor speeds is from 2 to 2¾ m. p. h.; in the 25–40 it is 1.4 to 2

m. p. h.; in the 40–60 and 60–90 it is 2 m. p. h.

All sizes have an enclosed differential and the final drive in the 16–30 is an enclosed internal bull-gear and pinion, while in the 25–45, the 40–65 and the 60–90 it is an external bull-gear and pinion. A top view of a *Twin City* 40–65 tractor is shown in *Fig. 10,* and a side view of a *Twin City* 60–90 tractor is shown in *Fig. 11.*

The Draw-Bar Pull.— The normal draw-bar pull of the 16–30 is 3,000 pounds; of the 25–45 it is 6,700 pounds; of the 40–65 it is 7,500 pounds, and of the 60–90 it is 11,250 pounds.

The Power Take Off.— The belt pulley speed of the various sizes at normal engine speed is as follows: for the 16–30 it is 528 r. p. m., for the 25–45 it is 600 r. p. m., for the 40–65 and the 60–90 it is 535 r. p. m.

The Yuba Ball Tread Tractors.— These tractors are built by the *Yuba Manufacturing Company,* of Marysville, Cal. The 20–35 tractor will pull six to eight plows, and costs $4,700, and the 40–70 will pull eight or ten plows and costs $6,250.

The Tractor Members.— Both of the above tractors are of the combine wheel and crawler type, having one wheel in front and two crawlers at the rear. The crawlers travel on large steel balls instead of on wheels, hence, the name *Ball Tread.*

The Power Plant.— Both tractors have engines of the *vertical* type with *four* cylinders; the normal speed of the 20–35 is 700 r. p. m., and the 40–70 is 600

r. p. m. The lubrication of both sizes is the individual pump positive feed type, and the cooling system includes a tubular radiator, a centrifugal pump and a fan. The fuel used is gasoline or distillate and this is fed to the carburetor by gravity, while a true high tension magneto is employed to fire the fuel charge.

The Transmission System.— In the 20–35 a multiple disk clutch is used while in the 40–70 the clutch is of the expanding shoe type. In both sizes the transmission is of the sliding gear type; the 20–35 has two speeds forward and one reverse and give a range of tractor speeds from 2.06 to 3.28 m. p. h., while in the 40–70 it has three speeds forward and one reverse and give a range of tractor speeds from 1.59 to 2.84 m. p. h. The 20–35 has no differential but the 40–70 uses an enclosed one. The final drive in both sizes is a bull pinion in the crawler links. It is illustrated in *Fig. 92*.

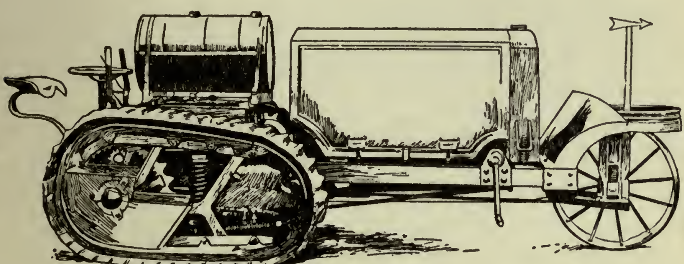


Fig. 92.— The Yuba Ball Tread 20–35 Tractor

The Draw-Bar Pull.— The normal draw-bar pull of the 20–35 is 5,000 pounds and that of the 40–70 is 10,700 pounds.

The Power Take Off.— The belt pulley speed of the 20–35 is 700 r. p. m., and that of the 40–70 is 600 r. p. m., when the engine is running at its normal speed.

Other Big Farm Tractors.— Besides the tractors enumerated above there are many others built for farm work, as the following table shows:

Table of Tractors Pulling Four Plows or More

F. C. Austin Co., Inc., Chicago, Ills.	20–40 *Austin*	4	Plows
Bethlehem Motors Corp., East Allentown, Pa.	18–36 *Bethlehem*	4	"
Bullock Tractor Co., Chicago, Ills.	18–30 *Bullock Creeping Grip*	3 or 4	"
Common Sense Gas Tractor Co., Minneapolis, Minn.	20–40 *Common Sense*	4 to 6	"
Dauch Mfg. Co., Sandusky, Ohio	15–35 *Sandusky E*	4	"
Depue Bros. Mfg. Co., Clinton, Iowa	20–30 *Depue*	3 or 4	"
Dayton-Dowd Co., Quincy, Ills.	16–36 *Leader C*	4 to 6	"
C. H. A. Dissinger and Bro. Co., Wrightsville, O.	15–30 *Capital*	4	"
" " "	25–45 *Capital*	8	"
" " "	40–80 *Capital*	10	"
Eagle Mfg. Co., Appleton, Wis.	16–30 *Eagle*	4	"
Evans Mfg. Co., Hudson, Ohio	25–30 *Hudson*	3 or 4	"
A. B. Farquhar and Co., Ltd., York, Penn.	15–25 *Farquhar*	3 or 4	"
" "	18–25 *Farquhar*	4 or 5	"
" "	25–50 *Farquhar*	6 or 7	"
Four Drive Tractor Co., Inc., Big Rapids, Mich.	20–36 *Fitch Model 4*	4	"
Grain Belt Mfg. Co., Fargo, N. Dakota	15–35 *Grain Belt*	4	"
Gray Tractor Co., Minneapolis, Minn.	18–36 *Gray*	4	"
Hollis Tractor Co., Pittsburgh, Penn.	15–25 *Hollis Model M*	3 or 4	"
Illinois Tractor Co., Bloomington, Ills.	18–30 *Illinois Super Drive*	3 or 4	"
Imperial Machine Co., Minneapolis, Minn.	40–70 *Imperial*	12	"
Interstate Traction Co., Waterloo, Iowa	15–30 *Plowman*	3 or 4	"
J. T. Tractor Co., Cleveland, Ohio	16–32 *J. T.*	3 or 4	"
Kinnard and Sons Mfg. Co., Minneapolis, Minn.	25–30 *Flour City*	4 to 6	"
" "	30–50 *Flour City*	6 to 8	"
" "	40–70 *Flour City*	8 or 10	"
Kohl Tractor Co., Cleveland, Ohio	17–35 *Kohl* L	3 or 4	"

TABLE OF TRACTORS PULLING FOUR PLOWS OR MORE—(*Continued*)

John Lanson Mfg. Co., New Holstein, Wis.	*15–25 Lanson Full Jeweled*	3 or 4 Plows
Lenox Motor Car Co., Hyde Park, Mass.	*20–30 Lenox American*	4 "
" "	*60–80 Lenox American*	8 or 10 "
Liberty Tractor Co., Minneapolis, Minn.	*15–36 Liberty*	4 "
Little Giant Tractor Co., Mankato, Minn.	*16–22 Little Giant B*	3 or 4 "
" "	*26–35 Little Giant A*	5 or 6 "
Minn. Threshing Machine Co., Hopkins, Minn.	*20–40 Minneapolis*	4 "
" "	*40–80 Minneapolis*	8 "
Monarch Tractor Co., Watertown, Wis.	*18–30 Neverslip*	4 "
Nelson Corporation, Boston, Mass.	*20–28 Nelson*	4 or 5 "
" "	*35–50 Nelson*	6 or 8 "
Nichols and Shepard Co., Battle Creek, Mich.	*35–70 Oil Gas*	8 or 10 "
" "	*25–50 Oil Gas*	4 or 5 "
Nilson Tractor Co., Minneapolis, Minn.	*24–36 Nilson Senior*	4 "
Pioneer Tractor Mfg. Co., Winona, Minn.	*18–36 Pioneer*	4 "
" "	*30–60 Pioneer*	10 "
Russell and Co., Massillon, Ohio	*20–40 Big Boss*	4 or 5 "
" "	*30–60 Giant*	8 or 10 "
Sampson's Sieve-Grip Co., Janesville, Wis.	*15–30 Sampson*	4 "
Sci. Farming Machinery Co., Minneapolis, Minn.	*10–20 Princess Pat*	2 to 6 "
" "	*25–50 Tank Tread*	4 to 12 "
Standard Traction Co., St. Paul, Minn.	*22–45 Standard*	4 "
Stimson Tractor Co., Superior, Wis.	*18–36 Stimson*	4 "
Topp-Stewart Tractor Co., Clintonville, Wis.	*20–30 Model B*	4 "
Townsend Mfg. Co., Janesville, Wis.	*15–30 Townsend*	4 "
Zelle Tractor Co., St. Louis, Mo.	*15–25 Zelle*	3 or 4 "

CHAPTER VIII

DRAW-BAR AND BELT POWER APPLICATIONS

As far as tractor power is concerned all farm machinery can be divided into two general classes namely (1) those that are hitched to the draw-bar, and (2) those that are belted to the pulley.

SOME DRAW-BAR APPLICATIONS

Where plows, harrows and other draw-bar implements are employed it is necessary, in order to get the highest efficiency, (*A*) to use those that are built especially for tractor work, and (*B*) to use the right kind of hitches.

Implements made especially for use with tractors are more serviceable than horse-drawn tools because they are more substantially built and, hence, stand up better under the stresses and strains to which they are subjected, while the matter of using right or wrong hitches often means the success or failure of the tractor in field work.

Why Hitches are Needed.— The reason hitches of various kinds are needed is (*a*) so that any kind of an implement can be coupled to the tractor, (*b*) so that two or more implements can be coupled to the tractor and used at the same time, and (*c*) so that the draft is lightened to the greatest possible extent.

Hitches for Plows and Harrows.— *For Plows.*— Hitches for use with either the modern tractor plow or the engine gang plow are usually taken care of by the manufacturers of these implements and of the tractors. Some tractor makers furnish a plow hitch formed of a plate with holes in it for the plow clevices. So you do not need to give the plow hitch any further thought.

For Harrows.— Neither do ordinary drag nor disk harrows need any other hitch than the draw-bar which the makers furnish with them as a regular part of the implement. But where a number of harrows are to be used abreast, a special hitch is needed. With a tandem disk harrow that has a fore-carriage, or *tongue-truck,* as it is called, fitted to it you will have to use a chain hitch which is long enough to keep the tractor, when it is traveling over uneven ground from exerting any pressure on the tongue truck.

For Plows and Harrows.— It is a good plan to harrow the ground as soon after it is plowed as possible for it is then in a moist condition and is much more easily and will be more thoroughly broken up than if it is allowed to remain exposed to the sun and wind for a time.

You can plow and harrow in one operation if you have a tractor of sufficient power, for all you need to do is to hitch a plow to the tractor and a harrow to the plow as shown in *Fig. 93*. Where a disk harrow is used, instead of the peg harrow shown in the cut, a rigid stub tongue takes the place of the chain in which case the coupling is made by means of a clevis.

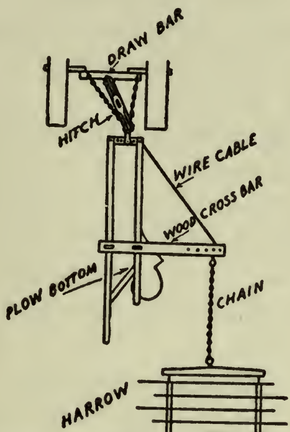


FIG. 93.— HITCH FOR ONE PLOW AND HARROW

Hitches for Listers, Cultivators, and Wagons.— No especial hitch is needed where a single lister, a cultivator, wagon, a combined wagon and hay loader, a lime, or manure spreader is coupled to a tractor, the stub tongue of these vehicles serving the purpose. Some makers equip their tractors with an automatic coupler so that it is easy to hitch on a wide variety of vehicles.

But where two or more vehicles or implements are to be used at the same time a special hitch must be employed. As an example, where a two row lister is used for planting corn a special hitch is needed, and, again, where two wagons are used with a hay loader a special hitch is also necessary. In these and in many other ways by doubling up the vehicles or implements the work can be greatly facilitated provided the right kind of hitches are used and this not only means a great saving in time but very often of saving the crop by getting it in in time.

Hitches for Mowers and Harvesting Machines.— A special hitch must be used to hitch up two or more mowers to a tractor as well as for harvesting machines; you can buy these hitches ready made or you can make them yourself according to what you figure your time is worth, the exigencies of the case and your inclination to do the job.

Commercial Hitches.— By this term is meant special hitches of every conceivable kind that are manufactured and marketed by various companies, the names of some of which are given below. By writing them your needs they will send you the information you want. Here is a list of companies that make hitches:

Deere and Co., Moline, Ills.; *Detroit Pressed Steel Co.,* Detroit, Mich.; *Emerson-Brantingham Implement Co.,* Rockford, Ills.; *Grand Detour Plow Co.,* Dixon, Ills.; *International Harvester Co.,* Chicago, Ills.; *La Crosse Plow Co.,* La Crosse, Wis.; *Meadows Mfg. Co.,* Pontiac, Mich.; *Oliver Chilled Plow Co.,* South Bend, Ind., and the *South Bend Chilled Plow Co.,* South Bend, Ind.

Home Made Hitches.— Wherever a special hitch is needed you can make it yourself at a very small outlay of time and money. All you have to do is to write to the *Secretary* of any of the following companies and he will send you gratis printed and illustrated instructions for making hitches of every kind which will fit every purpose.

Deere and Co., Moline, Ills.; *Emerson-Brantingham Implement Co.,* Rockford, Ills.; *International Harvester Co.,* Chicago, Ills., and the *Oliver Chilled Plow Co.,* South Bend, Ind.

About Draw-Bar Loadings.— You do not need to figure out how many plows your tractor will pull for the maker has carefully determined this factor basing it on all sorts of experimental data and practical tests. Hence, I'm telling you that your one best bet is not to use any more plows than the maker says your tractor will pull.

You will often be tempted, when you are plowing and find the tractor pulling along at an easy, steady-going speed to hitch on another plow, or a harrow or two, but this is mighty poor policy for it is just such additional loads that will be sure to make some part of the tractor break or else send it to the junk-pile when it would otherwise be giving you good service. Whenever you want to hitch on one or more implements take off one or more of those you have on so that the *draw-bar load* will always be well within the capacity of the tractor.

Plows Recommended for Normal Draw-Bar

Horse Power.— The following table gives the number of plows recommended by the makers, the normal draw-bar horse power of the tractor, the lowest and highest draw-bar horse power of the tractor and the normal pull in pounds at a speed of 2⅓ miles per hour which is the speed recommended for plowing by the *Society of Automotive Engineers.*

TABLE OF DRAW-BAR RATINGS

Plows Recommended	*Average Draw-bar H. P. Rating*	*Lowest and Highest Draw-bar H. P. Ratings*	*Draw-bar Pull in Lbs. at 2⅓ miles per hour*
1	5	5	800
2	10.2	6 to 17	1650
3	14	8 " 18	2250
4	17.1	12 " 20	2760
5	20.8	18 " 24	3500
6 and 7	23.3	20 " 27	3760
8 and 10	35	30 " 40	5600

How to Figure the Draw-Bar Pull of a Tractor. — To find the draw-bar pull of a tractor for a speed of 2⅓ miles per hour use the following formula:

$$\text{Draw-bar Pull in Pounds} = \frac{\text{Average Draw-bar Horse Power Rating} \times 33{,}000 \text{ Foot Pounds}}{\text{Speed per Minute in Feet.}}$$

Now let us take an example. The plowing speed is 2⅓ miles per hour, or 205 feet per minute. Suppose you want to find the draw-bar pull of a tractor having an average draw-bar horse power rating of 14 traveling at the plowing speed of 205 feet per minute, then substitute these figures for the terms in the above formula, like this:

$$\frac{14 \times 33{,}000}{205}$$

By working this out you will find that

$$\frac{462{,}000}{205} = 2{,}250$$

and 2,250 is the *draw-bar pull in pounds.*

If you want to use some other speed than the standard one of $2\frac{1}{3}$ miles per hour, or 205 feet per minute, you must reduce the speed in miles per hour to feet per minute and substitute as before in the above formula.

SOME BELT POWER APPLICATIONS

In buying a tractor be sure to get one large enough to do all of your belt work for with some of the smaller sizes it frequently happens that the power take off is not enough and then you will either have to buy a stationary engine or go out and hire one. In any event you will have to pay extra for the power that your tractor ought to deliver.

The Grain Thresher.— About the hardest work that a tractor has to do, as far as belt work is concerned, is running a thresher. The makers generally recommend the size of thresher that can be run with their tractors just as they recommend the number of plows they will pull.

The diameter of the belt pulley on threshers varies with different makers from 5 to 12½ inches and the face varies from 4 to 10 inches; the pulley speed ranges from 300 to 1,300 r. p. m., and the horse power required to run them is anywhere from 8 to 80. How to make your thresher, and the other machines which follow, run at the speed recommended and still keep the speed of your engine normal will be told presently.

The Corn Husker and Shredder.— This machine is used to husk the corn and shred the fodder when the latter is called *stover* and is used to feed farm stock. The power take-off of the tractor is largely used in the corn growing belts to run these combined huskers and shredders. The diameter of the belt pulley on huskers and shredders varies from 5 to 16 inches and the face varies from 6 to 10½ inches while the pulley speed ranges from 500 to 1200 r. p. m., and the horse power from 6 to 25 according to the size.

The Hay Baling Press.— The purpose of baling hay is to make it easy to handle and compact for shipping and storing. There is only about 5 pounds of loose hay in a cubic foot while it weighs 40 pounds per cubic foot after it is baled. To compress it to this extent requires power and, hence, this is another machine on which the belt of a tractor gets in its fine work.

The pulley diameters of different makes of hay presses vary from 8 to 44 inches and the faces vary from 7½ to 9½ inches; the pulley speeds range from 185 to 750 r. p. m., and the horse power required to run them is from 4 to 35.

The Ensilage Cutter and the Silo.— The word *ensilage,* or *silage* as it is called for short, means a fodder made by cutting up green corn stalks, alfalfa and other vegetable matter, into short pieces and this is preserved in a *silo* which is an air-tight tower. The silo is widely used on farms throughout the country, for silage provides a valuable green food for farm animals during the winter months.

The matter of cutting the silage and of filling the silos with it takes power and this is part of the belt work that nearly every tractor has to do. The diameter of pulleys of ensilage cutters varies from 5 to 20 inches and the face from 4 to 14 inches. The speed ranges from 400 to 1,200 r. p. m., and from 3 to 35 horse power is required to drive them according to size.

The silos are filled by elevators on the cutters that convey the silage to the top and dumps it in. There are two kinds of elevators used and these are (1) the *double chain conveyer,* or *web carrier elevator,* and (2) the *blower elevator.* In the latter type the silage is blown up and into the silo by a rotating fan.

The Corn Sheller.— A corn sheller is, as its name fairly indicates, a machine that shells the corn from the cobs. There are two kinds of these machines, namely, (1) the *spring sheller* and (2) the *cylinder* *sheller.* A spring sheller has picker wheels while a cylinder sheller has a cylinder with ribs fixed to it. Nearly all shellers have self-feeders that convey the corn-on-the-cob to the separating mechanism.

The diameter of the pulley wheels varies from 6 to 26 inches and the face varies from 2 to 12 inches; the speed recommended ranges from 200 to 1,100 r. p. m., while from 1 to 28 horse power is needed to run them according to the capacity of the machine.

The Feed Grinder.— Feed grinders are made to grind all kinds of grain for feed purposes. The grinding is done by means of either (1) *rollers,* or by (2) *burrs* which are roughened disks. These burrs are usually of steel but when a fine meal is wanted burrs of stone are used. It is between these rotating elements that the grinding is done.

Grinders are often fitted with elevators so that the ground grain can be sacked in one operation. The diameter of the pulleys varies from 4 to 16 inches and the face varies from 3½ to 12 inches. The speed they run at varies from 200 to 1,600 r. p. m., and it takes from 1 to 30 horse power to operate them.

TRACTOR PULLEYS AND BELTS

The Speed of Machines.— A machine of whatever kind must be driven at the speed it was built for, for if it is driven too fast it will wear itself out in no time and if it is driven too slow it will waste the power and may fail to do good work.

Now the pulley speeds of tractors and of farm machines are *arbitrary,* that is, every maker fixes the speed at which his machines are to run without regard to any standardized rule, consequently, when you buy, say a corn sheller, you will quite likely discover that it will not either begin to develop the speed the maker recommends, or it will run at far too high a speed, when it is belted to the pulley of the tractor. So your first job will be to put on a pulley that will give the right speed.

If the speed of the machine is a little too fast or too slow you can adjust the governor on your engine to make up the difference. The better way, though, is to provide all of your machines with the proper sized pulleys and then all you will have to do, when you want to use any one of them, is to *back your tractor into the belt,* as it is called, throw on the power and you are ready for work.

How to Find the Speed of a Pulley or a Belt.— It is often convenient to know the speed a shaft or a pulley is making. It is easy enough to do this by using a *speed indicator* — a little mechanical device that you can buy at any tool store for a couple of dollars.

The way to find the *number of revolutions per minute* a shaft or pulley is running at is to press the end of the indicator against the center of the shaft, or by putting a wheel on the indicator shaft and pressing it against the face of the pulley or a belt you can find the *surface speed* of it, that is, the number of feet it is moving in a minute.

How to Find the Size of a Pulley.— In order to run any farm machine at its proper speed, that is the speed which the manufacturer recommends as the best, you must be able to calculate the size of the pulley needed on the machine.

The pulley on your tractor is, of course, of a fixed size and if you want to run, say, an ensilage cutter at a given speed, a *ratio* between the sizes of the tractor pulley and the ensilage cutter pulley must be had. You can easily find the size needed by using the following formula:

$$\text{Diameter of Machine Pulley} = \frac{\text{Diam. of Tractor Pulley} \times \text{R.P.M. of Tractor Pulley}}{\text{R.P.M. of the Machine Pulley}}$$

Now let us take an example. An ensilage cutter, or other machine, is to be run at a speed of 800 r. p. m., by a tractor whose pulley is 16 inches in diameter and which is driven at a speed of 400 r. p. m. What must be the size of the pulley on the ensilage cutter or other machine?

Substituting now the known figures for the formula above we have

$$\text{Diameter of Machine Pulley} = \frac{16 \times 400}{800}$$

or worked out

$$\text{Diameter of Machine Pulley} = \frac{6400}{800} = 8 \text{ inches}$$

and 8 inches is the diameter of the pulley you want on your ensilage cutter or other machine.

How to Find the Belt Speed.— The belt speed of your tractor is the rate of travel of any one point on the belt and it is measured in feet per minute. You can find it by the following formula:

$$\text{Belt Speed} = \frac{(\text{Diameter of Tractor Pulley} \times 3.1416) \times \text{R.P.M. of Tractor Pulley}}{12 \text{ inches}}$$

where the diameter of the tractor pulley $\times$ 3.1416 = the circumference of the tractor pulley in inches.

As an example, suppose the diameter of the tractor pulley is 18 inches and its speed is 550 r. p. m. Substituting these figures in the formula we have,

$$\text{Belt Speed} = \frac{18 \times 3.1416 \times 550}{12}$$

or,

$$\text{Belt Speed} = \frac{31{,}200}{12} = 2{,}600 \text{ feet,}$$

and 2,600 feet is the speed of the belt in feet per minute.

CHAPTER IX

HOW TO TAKE CARE OF YOUR TRACTOR

More tractors go to the scrap heap every year for the want of care than because of wear. If a tractor is built right to begin with and is operated and taken care of right afterward there is no reason why it should not give good service for a period of ten years.

But very few tractors are built right, for their design and construction is a new and a difficult branch of automotive engineering and, hence, nearly all, if not all, of them have their weak points. Then, they are generally run by men who have had little or no experience with tractors, and added to the above untoward features is the greater one of gross negligence in failing to take reasonable care of it. The net result of it all is that the tractor *kicks in* after a couple of years and the owner *kicks* himself for having bought it.

Running the Tractor Yourself.— Because the tractor is built up of a number of finely organized and highly specialized units does not prevent any one of ordinary intelligence from running it just as any one can drive a motor car or a motor truck after he has been shown how a couple of times though he may not know the difference between a piston ring and a wrist pin.

If you are going to run the tractor yourself, or have some member of your family run it — and this is usually the best way to begin to treat it right — you ought to do one of two things, namely (1) to get some one who really understands tractors to teach you all he can about it, or (2) go to some motor car school where tractioneering is taught and take the course in operating and caring for it.

Nearly all tractor companies offer a course of instruction in the use of their tractors at a nominal fee and you should by all means take advantage of it for any small outlay you may make in the beginning will be returned to you a hundred fold later on.

No sane farmer would think for a moment of letting a callow city youth take entire charge of his team of $800 horses without previous experience, but many otherwise sane farmers turn their brand new $5,000 tractors over to Jim, Jack or Bill because they know how to fix the gears on a windmill or a pumpjack. The ultimate result will be the same in either case, *i. e.,* the horses will go to the bone-yard and the tractor will go to the junk-pile in short order. No, if you are going to use a tractor and make it pay on your farm you have got to know the *innards* of it so that you can scent where the trouble is the moment it shows up and be able to take care of it at once instead of letting it go until it develops into a breakdown.

About Hiring a Tractioneer.— If you are up against the proposition of hiring a man to run your tractor try, if possible, to get one (1) who naturally likes machinery, for he will be likely to take good care of it, (2) who has run a gasoline or an oil engine, (3) who knows something about heavy duty machinery, and, finally, (4) who has worked on a farm.

To put your hand on such a good man Friday is, of course, well nigh, impossible but you can take a chance on a fellow who possesses two or three of the above qualifications. Another, and an excellent way to get the makings of a tractioneer is to write to the tractor schools for one, for they are constantly turning out any number of good, steady, ambitious young fellows and all they need is a little practical experience.

Taking Care of Your Tractor.— There are only four things that you have to look after all the time on a tractor and these are (1) the *lubricating system,* (2) the *cooling system,* (3) the *fuel system,* and (4) the *ignition system.* The things that you have to look after once in a while will be enumerated presently.

Keeping the Tractor Oiled.— The two chief parts of a tractor that need constant lubrication are (1) the engine and (2) the transmission system, and the oils used for these parts are of very different kinds. Now the great secret of taking good care of your tractor is (*A*) to keep it lubricated with the right kind of oil and grease, and (*B*) to keep it well oiled all of the time, for nothing makes a tractor go to pieces so quickly as the want of oil, and next to this is the want of the proper kind of oil.

Lubricating the Engine.— Different from a motor car or a motor truck engine the engine of a tractor is working all the time at full load and, consequently, the high power explosions heat the cylinders to a much higher temperature than in the engines of the two just named types of vehicles.

This means, then, that an oil must be used to lubricate the tractor engine that is heavier and has a lower volatility, or *flash test,*[1] as it is called, than ordinary motor car oils. As a general rule, where the engine has a splash and circulating system, a heavy lubricating oil is needed, but where the individual pump positive feed system is used an extra heavy oil is necessary.

The maker of your tractor will tell you the right grade of oil to use for the engine as well as the make of oil he prefers and you should by all means follow his instructions for his information is based on long experience and various kinds of costly tests. Or you can write to the *Tide Water Oil Company,* 11 Broadway, New York, or the *Vacuum Oil Company,* 100 Broadway, New York, and either firm will tell you exactly the kind of oil you should use and they will tell you right.

Lubricating the Transmission System.— The transmission systems of all tractors are about alike, and *Fig. 94* shows one in which the transmission runs in oil and the differential is exposed, while *Fig 95* shows

[1] The *flash test* is the lowest temperature at which the vapor from an oil will ignite but not keep on burning.

the lubricating system of a *Fordson* tractor where all of the rotating parts run in oil. Either a *semi-fluid oil* or a *gear compound* is used and this is poured into the transmission case through the *filling plug hole* until it begins to run out of the *constant level plug hole.*

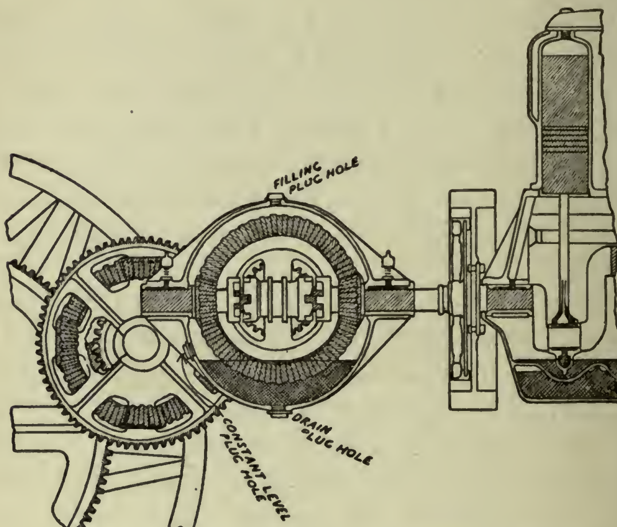


FIG. 94.— A TRANSMISSION LUBRICATING SYSTEM

When you want to drain off the oil remove the *drain plug* at the bottom of the case.

All transmission gears, chain drives and bull-gears and pinions that are not enclosed can be lubricated with a cheap drip oil or a heavy adherent gear grease. The transmission shafts, drive shafts and wheel bearings are usually fitted with grease cups though in some tractors these are lubricated by a unit oiling system. When you get your tractor screw down the grease cups until the grease oozes out of the sides of the bearings as they require more grease when the tractor is new.

A Few Lubrication Don'ts.— Don't fail to get a *lubrication chart* from the dealer you buy your tractor of as this shows you where every part of it is to be

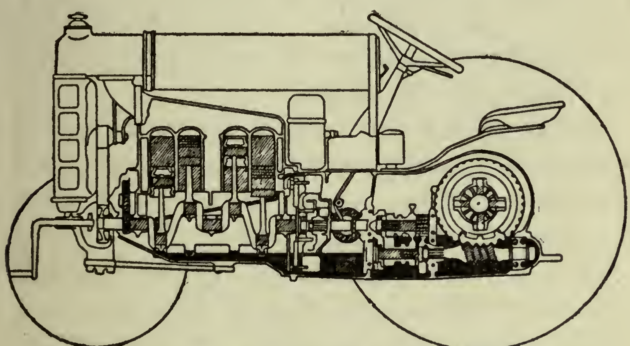


FIG. 95.— LUBRICATING SYSTEM OF A FORDSON TRACTOR

oiled and how often it is to be oiled. Don't use a pail that has dust on or dirt in it for carrying oil from the supply barrel to the engine.

Don't fail to cork up the barrel after you have drawn oil from it. Don't let the pail of grease remain open, especially if you carry it on the tractor with you, but always keep it covered with an air tight cover; grease with dust or dirt in it is worse than no grease at all. Don't start the engine unless you know to a certainty that there is plenty of oil in the sump or tank.

Keeping the Engine Cool.— *Water Cooling.*— Where water is used for cooling the engine see that it is never lower than the three-quarter level in the radiator but always keep it full if possible. Low water reduces the cooling capacity of the radiator and this will cause the engine to heat up. Use only clean, pure water — rain water is the best — and strain it before you put it into the radiator. Every tractor has a strainer in the filler of the radiator and be sure to see that it is always in there.

Should you ever be so careless as to let the engine run without water, or with the water failing to circulate, the pistons may become heated to such an extent that they will stick in the cylinders.

In this event pour enough engine oil into the cylinders to fill them and crank the engine until the pistons again work smoothly. If the pistons are badly stuck you may not be able to crank it even with the oil in the cylinders. By pouring some kerosene in the oil the pistons will be eased up so that you can turn the crank provided they have not been too badly damaged.

Water Cooling in Winter.— When freezing weather comes on protect your engine against it by either (1) opening all of the drain cocks and letting the water run out of the water cooling system every night, or (2) pouring an *anti-freezing solution* into the radiator made of *25% of wood alcohol, 15% of glycerine* and

60% of water. This solution will not freeze if the temperature does not fall more than *10* degrees below *0 Fahrenheit.*

A Couple of Water Cooling Don'ts.— Don't use a pail to fill the radiator with that has had oil in it for the oil will form a coating on the inside or outside of the tubes and this will reduce the radiation of the heat. Don't let dust, dirt or any other matter get into the radiator for enough of it will keep the water from circulating properly.

Oil Cooling.— Oil is used in some engine cooling systems because (1) it does not boil, and, hence, (2) it will not evaporate, and (3) it will not freeze. Any good light lubricating oil or high test kerosene can be used. The disadvantage of using oil is that it does not radiate the heat nearly as rapidly as water.

Fan Cooling.— One of the common faults that causes an engine to overheat is a fan belt that slips. When you put on a fan belt be sure the smooth side, that is, the *hair* side, is next to the pulley, and the rough side, or *flesh* side, is outside.

Caring for the Fuel System.— *The Kind of Gasoline to Use.*— In buying gasoline get as good a grade as you can for the best is none too good these days. You can make rough tests of gasoline with a *hydrometer* in the same way that you test the solution of a storage battery with it. A grade of gasoline that has a *specific gravity*[1] of *65* or *70* degrees *Baumé* is all right for your tractor engine but the grade that you are

[1] See any text book on *Physics.*

most apt to get has a specific gravity of 60 to 70 degrees.

It is usually easy to start the engine on a high grade of gasoline, and sometimes it is very hard to start it on a low grade gasoline, especially in winter. If you are using a low grade of gasoline, or kerosene or other fuel oil, keep a gallon or so of high grade gasoline on your tractor — most tractors are provided with a tank for this purpose — to start the engine with and you will have no trouble on this score.

Whatever kind of fuel oil you use be sure to filter it through a piece of chamois skin to prevent particles of dirt and sand from going through the fuel system and into the cylinders. Filtering the fuel oil will also remove any water there may be in it. You must take care to keep the lint of cotton waste from getting into the feed pipe for it will stop up the fuel inlet of the carburetor, which has a fine strainer over it, and this will prevent the fuel from flowing through, and, of course, the engine will stop.

The Kind of Kerosene to Use.— Kerosene is not as good a fuel for tractor engines as gasoline and unless it is completely vaporized it will form heavy deposits of carbon in the cylinders. Formerly water had to be injected into the cylinders with the fuel mixture to prevent the carbon from coating the cylinder walls but recent improvements in preheating the fuel mixture permits kerosene to be used very satisfactorily without the use of water.

The kind of kerosene that is used for engines is of a lower grade, i. e., of a lower *fire point*[1] than that used in lamps. The latter has a fire point of 140 to 150 degrees *Fahrenheit* while the former has a fire point of only 100 to 110 degrees *Fahrenheit*. The lower grade, however, makes a better fuel oil than the higher grade for it ignites at a lower temperature, evaporates more readily and is considerably cheaper. Since it costs only about half as much as gasoline this factor compensates for whatever shortcomings it may have.

About Heavy Fuel Oils.— The same care must be exercised in using kerosene, distillate and other heavy fuel oils that is prescribed for gasoline.

Caring for the Ignition System.— Nearly all tractors are equipped with a *magneto* for firing the cylinders as they should be. Where a *storage battery and circuit breaker* system is used you must see to it that the battery does not get weak or run down. With a magneto there is nothing to do except to give it a little oil and clean the spark plugs. Although the magneto is an enclosed piece of electrical apparatus it should have a leather case fitted over it to keep it from getting wet.

The *spark plugs* must be looked after to see that the electrodes are in good condition and that they are *gapped* right, that is the distance between the points of the electrodes form the right length of *spark gap*.

[1] The *fire point* is the lowest temperature at which the oil will ignite from its vapors when a small flame is brought near it and quickly taken away.

Keeping Your Tractor Clean.— By this sign shall ye be known, namely, the way your tractor looks. To keep your tractor clean is an important matter not because it looks good but because it spells economy. Clean the engine with waste, wipe or wash the dust and dirt off of the radiator, hood and exposed parts and if there is mud on the traction members, and especially the bull-gears, scrape it off and your tractor will run the better for it. Then run it under cover and throw a tarpaulin over it.

SUMMARY OF HOW TO CARE FOR YOUR TRACTOR

Daily Care and Upkeep.— The first thing in the morning go over every part of your tractor and see that it is fit and ready for the day's run. Begin by seeing (1) that the connecting rod bearings are tight and if not take them up; (2) that every bolt and nut is tight, and (3) that every part of the tractor is intact. (4) Fill the sump of the engine, or tank, with lubricating oil, fill the bull-gear oilers and fill and screw down all of the grease cups. (5) Put a couple of drops of light machine oil on the bearings of the magneto. (6) Fill the fuel oil tanks, and (7) fill the radiator with water. (8) Whenever you make a stop feel of all of the engine bearings to ascertain if they are cool and see that they are getting all the oil they need.

Weekly Care and Upkeep.— At the end of every week (1) drain the oil out of the crank case of the engine, the pipes and the pump and flush them out with gasoline or kerosene and then put in fresh clean oil. (2) See that the oil in the transmission case is up to the constant level plug. (3) Drain the water out of the cooling system and fill it with clean water, and (4) take out the spark plugs, clean them and see that they are *gapped* right.

(5) Where the tractor is working 10 or 12 hours a day the exhaust valves must be *ground* at least once every other week, but where the engine is running 18 or more hours a day they must be ground every week. This grinding operation is to make them *seat* properly and so prevent a loss of compression in the cylinders. The inlet valves seldom require grinding for the fuel mixture that strikes them is cool compared with the burnt gases that strike the exhaust valves. It is a very simple matter to grind these valves and I will tell you how to do it in the next chapter.

Finally (6), *every month* drain the oil out of the transmission case, flush it out clean with kerosene and fill it with clean oil.

Care at the End of the Season.— When you are all through with your draw-bar and belt work for the season (1) run your tractor under cover where it will be well protected from the rigors of winter. (2) Pour a quart or so of semi-fluid oil into each cylinder and crank the engine so that it will form a thick film on the cylinder walls. (3) Take off the cylinder head, or valve caps, and smear some semi-fluid oil on the valves and valve seats. Then put some thick oil on the threads of the valve caps and screw them back on tight, all of which is done to prevent the moisture that forms inside of the engine during the winter months from rusting it. See to it that the prime and relief cocks are shut tight. Then, (4) run off the oil in the gear case and wash it out with kerosene.

(5) Drain off the water from the water cooling system and take off all the cocks. (6) Shut off the cock at the fuel tank and drain off the fuel oil from the pipe and carburetor. (7) Either take off the magneto and put it away in a perfectly dry place or else tie a couple of thicknesses of canvas around it. Likewise cover the governor and the carburetor with canvas, and, (8) either take off the fan belt, or cover it with canvas.

Finally, (9) as you are going over the tractor make a note of every new part you will need the following spring to put it in good shape and then and there write out a list of them. Some time during the winter send your order in to the manufacturer so that you will be sure and have everything you need when you want it.

When spring rolls round again start in by (1) taking off all the covers, then, (2) remove the semi-fluid oil from the cylinders, this you can do by the liberal use of kerosene, and see that they are well washed out. (3) Pour a quart or so of the kind of lubricating oil you use into each cylinder, and crank the engine until all of the oil has run down into the crank case. (4) Prime the cylinders with gasoline and put a little lubricating oil in with it so that there will be enough oil to lubricate the pistons and cylinders until the lubricating system begins to work, and last of all (5) fill the transmission case with fresh oil or grease and you are ready for work again.

The Price of Tractor Economy.— If you will do all of the above things conscientiously you will add years to the life of your tractor and dollars to your bank account for eternal vigilance is the price of tractor economy.

CHAPTER X

TRACTOR TROUBLES AND HOW TO FIX THEM

In running a tractor you will run up against two kinds of trouble, namely, (1) those that are a mere matter of adjustment, and (2) those that are of a more serious nature caused by breakage. In this chapter we will look into the first kind and in the next chapter we will take care of the second.

The Symptoms of Trouble.— You will know when an adjustment of some kind is needed by the way the engine behaves. Now there are three general symptoms that indicate trouble and these are (1) when the *engine knocks,* (2) when the *engine overheats* and (3) when the engine *loses power.* In any event when these symptoms show up stop the tractor at once and find out what the trouble is.

When the Engine Knocks.— The chief causes that make an engine knock are (1) having the spark advanced too far; (2) the fuel mixture is not properly proportioned; (3) the bearings have too much play; (4) there is carbon in the cylinders, or (5) there is a piston slap.

Adjusting the Spark Control.— One of the commonest causes of knocking is having the spark advanced too far, by which is meant that you have pushed the spark control lever so far ahead that the spark takes place in the cylinders before it ought to and so fires the fuel charge prematurely. Try pulling the spark lever back a couple of notches.

Proportioning the Fuel Mixture.— Where knocking is caused by an improper fuel mixture adjust the air valve, or change the position of the nozzle of the carburetor so that the mixture is made *leaner,* that is, so that it will use more air and less gas. When the fuel mixture is right the color of the exhaust will be clear with a bluish tinge and it will have a sharp sound.

Taking Up the Bearings.— A good tractioneer will not wait until he hears the engine pounding to find out it is a loose bearing that is doing it but he will test the bearings religiously every week. To test a bearing turn the crankshaft over to a position where you can put a bar under the rod cap of the connecting rod and pry it up and down when you can easily tell if it is loose or not.

The Connecting Rod Bearings.— Between the connecting rod and its rod cap there are a number of *shims,* see *C* in *Fig. 14,* page 39, which are pieces of metal a little thicker than a sheet of writing paper. If the bearing is loose unbolt the rod cap, take out one or more of the shims and bolt the rod cap to the rod again.

Many engines are fitted with *laminated shims* and when you want to tighten up the bearing one or more of these can be peeled off. You must take pains not to get the bearing too tight or you will have to add one or more shims cut out of writing paper until the bearing has no play and yet runs easily. Always put the cap back in its original position, that is without turning it around, and be mighty careful you do not get dust or dirt on it.

The Crankshaft Bearings.— You can test the crankshaft bearings in the same fashion as the connecting rod bearings, that is by prying them up and down. In taking up these bearings do the work on one first and then on the other. This makes it easier to tell when the bearings are tight enough. When the bearings have become so worn that you have to put in new ones you can get *bronze backed babbited* bearings of the maker of your tractor.

To Remove the Carbon.— When there is too much lubrication oil used, or it is of too poor a grade, or where the fuel mixture is too rich, or crude fuel oils are used, they leave fine particles of carbon behind in the cylinder and this is very injurious to the walls of it and frequently causes the engine to knock.

To get the carbon out of the cylinders of an L or a T head engine remove the valve caps and turn the crankshaft over until the piston is on its top dead center. It is now possible to reach the head of the piston where the carbon chiefly gathers and with scraping tools made for the purpose you can scrape the carbon loose and into the exhaust passage. See *Fig. 96*.

In an engine that has a removable head you will have to uncouple the valve springs and take it off. You can then easily reach the piston head and clean the carbon off of it with the scraping tool as before. In either case, when you have scraped it out, brush all

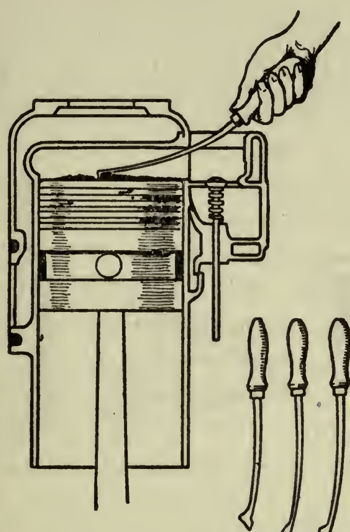


Fig. 96.— Removing the Carbon from a Cylinder

of the loose particles out with exceeding care and then wash all of the parts off with kerosene.

Remedying the Piston Slap.— Sometimes a connecting rod will get bent a little or the piston rings will become so worn that there will be a loss of compression and either of these defects will cause the engine to knock. The remedy is to replace the offending rod or rings with new ones.

Replacing Piston Rings.— To tell which piston is leaking take off the side cover plates from the crankcase, put your ear to the opening and have your helper turn over the crank. If you listen now you can hear the sound of the escaping gas as the pistons work against compression and so tell which one it is that leaks.

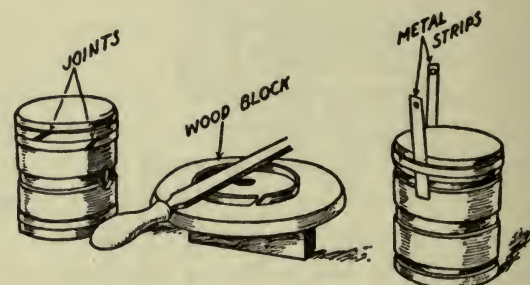


FIG. 97.— REMOVING PISTON RINGS

If you find black spots on a ring, or rough spots on the surface, or on the ends of it, put in a new one. In putting in a new ring see that it fits in the groove snug but it must not bind. The ends of the ring must have a clearance of 1/64 of an inch where they come together, after the piston is in the cylinder.

To take a ring off of a piston slip three or four thin strips of tin, or brass, ½ an inch wide and 6 inches long, under the ends of the ring and work them along until they are at equidistant points between the ends of the ring as shown in *Fig. 97;* you can then push the ring from the groove it sets in and so take it off.

To put a new ring on a piston slip the ring over the strips of metal, push it down until it is over the groove into which it is to go and then pull out the strips.

When the Engine Overheats.—There is an even dozen of sufficient causes that make an engine overheat and these are (1) too late a spark; (2) a slipping fan belt; (3) not enough, or too poor grade of lubricating oil; (4) a lack of water; (5) the water system is choked up; (6) the water pump impeller is damaged; (7) a choked up muffler; (8) carbon in the cylinders; (9) overload on the engine; (10) racing of the engine; (11) piston rings too large for the cylinders, and (12) valves that are not timed correctly. The thing to do to remedy most of the above defects is obvious but the others need some explanation.

Adjusting the Spark Control.— A frequent cause of overheating lays in having the spark over retarded, that is, you have pushed the spark control lever back so far that the spark takes place after it ought to and so fires the fuel charge too late. Try pulling the spark lever ahead a few notches and note the effect on the engine.

Tightening the Fan Belt.— When a fan belt slips the fan fails to pull the air through the radiator and this reduces its heat radiating capacity. This causes the engine to overheat and if not attended to at once it is liable to do a lot of damage to the engine. To tighten a fan belt tighten up the idler, or if the engine is a late model screw up the nut on the spring that increases its tension.

Replacing the Water Impeller.— After long use the blades of the impeller of the centrifugal pump become worn and once in a while a blade may break. In either case put a new impeller in the pump. When you put the pump back in place see that the stuffing box is screwed up or it will leak.

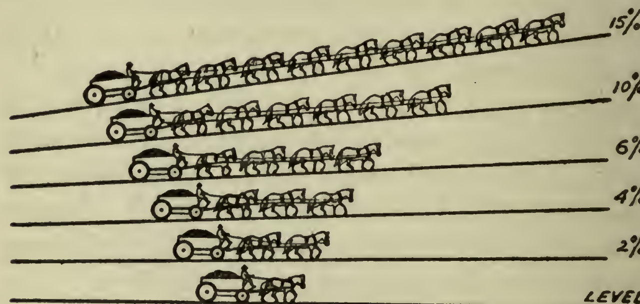


Fig. 98.— Graphic Representation Showing the Extra Horse Power Needed on Grades

Lightening the Load.— Overloading the tractor either at the draw-bar or the power take off is a common and disastrous practice. This is generally due to the fact that the tractioneer does not give a thought to the kind or condition of the road he is travelling over or what the grade may be. *Fig. 98* shows graphically the extra horse power it takes to pull a given load on different grades.

When a tractor pulls a loaded wagon of given weight on sandy soil it takes about 7 times as much power as when it pulls the same load on a smooth hard road. Further, for every 1 per cent. of grade, it takes as much additional power to pull it as though you added to the load 1 per cent. of the weight of it when the tractor is hauling it on a level road.

When the Engine Races.— Next to a lack of oil, *racing* the engine is the quickest way to destroy it. By *racing* is meant running the engine at speeds way above the normal. Sometimes this is, foolishly, done intentionally, but once in a while it results from a defective governor.

When racing occurs see that all of the pipe connections of the governor are tight and that none of the lock nuts have worked loose. Then adjust the governor until it gives the speed you want. If it won't make the engine respond you can conclude that there is something very much the matter with it. Don't try to fix it but write, or wire, the maker of your tractor, or his nearest distributor, when a new one will be shipped to you and when you get it you can send the old one back.

Using Piston Rings that Fit.— Where the piston rings are too large for the cylinders the *friction* will be excessive and consequently the *wear* will be proportionately great and no amount of oil will keep it down. The only remedy is to get piston rings that are not too large. The way to put on piston rings has already been described.

Timing the Valves Correctly.— When the valves are not *timed* correctly, that is when they do not open and close at the precise instant they should, the fuel is not only wasted but the engine overheats as well. It is not likely that the timing of the valves will be thrown out of adjustment provided the crankshaft, or the camshaft, or both, have not been disturbed when putting in new bearings or taking up old ones.

As the inlet and exhaust valves are operated by the *rotation* of the camshaft which is geared to the crankshaft it is natural that the time of their opening and closing should be determined in degrees. Since the flywheel, which is keyed to the crankshaft, is a *circle* and there are *360 degrees* in a circle, lines are cut on the flywheel to indicate the position of the crankshaft and the *time* when the valves shall open and close.

These lines on the flywheel must, of course, coincide with some fixed line and this is cut on the frame. Different makers use various marks to indicate when the inlet and exhaust valves open and close, but as an illustration let's suppose that the following marks are used, namely, (1) *In O* which means *intake open,* (2) *In C, intake closes,* (3) *Ex O, exhaust opens* and *Ex C exhaust closes,* as shown in *Fig. 99.*

Now when the line *In O* on the flywheel coincides with the line on the frame the crankshaft is in such a position that you want to set the camshaft so that the inlet valve is just starting to open on the intake stroke. Likewise, when the line marked *In C* on the flywheel coincides with the line on the frame the intake valve must start to close; when the line marked *Ex O* is even with the fixed line the exhaust valve must just start to open on the exhaust stroke and, finally, when the line *Ex O* is even with the fixed line the exhaust valve must start to close.

Besides these valve lines there are two other lines

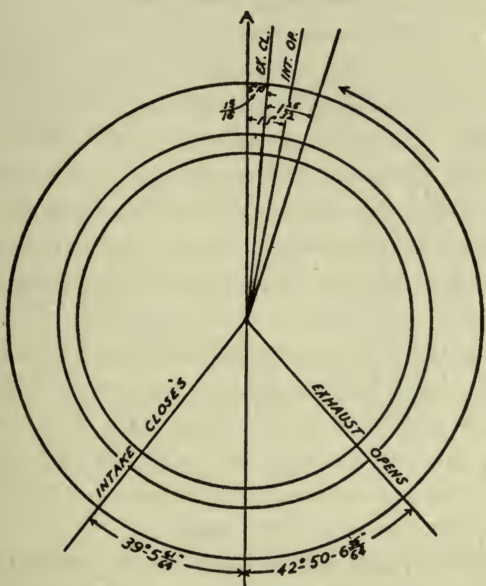


FIG. 99.—DIAGRAM FOR TIMING VALVES

that show the dead centers of the crankshaft. As the crankpins of a four cylinder engine set opposite each other on the crankshaft two sets of lines and marks are cut on the flywheel at an angle of 180 degrees apart. Finally see to it that the right distance is had between the valve stem and the push rod or the valves will not open and close at the instant indicated by the lines on the flywheel.

When the Engine Loses Power.— When the engine begins to lose power you will know that it is due to one of the following causes, to wit, (1) too late a spark, (2) valves that are not timed right, (3) loss of compression, (4) too rich a fuel mixture, (5) overheating of engine, or (6) the exhaust valve springs are too weak. How to remedy all of the above troubles has been explained except the last two, though the first may involve the retiming of the magneto.

Timing the Magneto Correctly.— If the power of the engine does not pick up when you advance the spark then see if the magneto needs retiming. To time the magneto turn the crankshaft over to the point where both the inlet and the exhaust valves in cylinder *No. 1*, which is nearest the radiator,[1] are closed when the line on the flywheel and on the frame coincide. Now remove the covers from the distributor and the interruptor, which are on the magneto.

Next turn the interruptor box counter clockwise, that is, so that the top of it moves to the left when it will be in the retard position. This done turn the armature shaft around clockwise, with your fingers, which is its direction of rotation, until the contact points of the interruptor just begin to open and the contact arm of the distributor is on the left hand lower

[1] This does not apply to horizontal engines or vertical engines that set horizontally on the frame.

contact, see *Fig. 100,* and which is connected with the spark plug of the *No. 1* cylinder.

As the piston is at the top dead center of the *No. 1* cylinder and the contact points of the interruptor are just ready to snap apart, which induces the current that makes the spark, the magneto is then correctly timed so that it will fire the fuel charge in cylinder *No. 1,* and also the other cylinders in succession at the right instant.

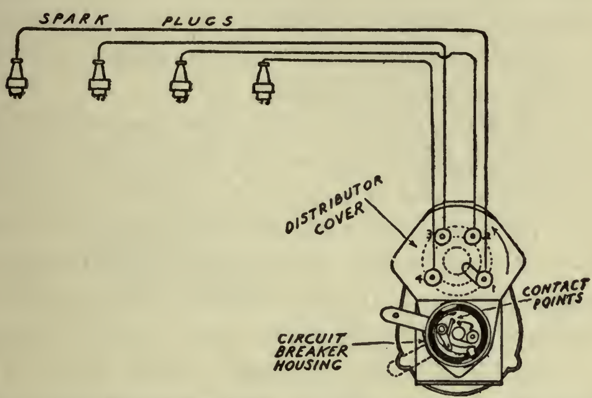


FIG. 100.— MAGNETO TIMING DIAGRAM SHOWING HOW THE MAGNETO IS TIMED

Now couple the armature shaft with the pump, or other shaft it is run by, by tightening the nut that holds the joint together. In doing this be mighty careful that you do not turn the armature one way or the other the smallest fraction of an inch. If the magneto is fitted with an impulse starter it must *trip* just as the line mark on the magneto coincides with the indicator line cut in the frame.

The armature shaft and the pump, or other shaft, which drives it, are coupled together by a flexible joint,[1] or *oldham joint* as it is sometimes called. This joint allows the magneto to be taken off and put back on easily and quickly. The two shafts when coupled up, however, must be absolutely in alignment or the strain on the magneto will make it vibrate and this will soon wear out the bearings.

Loss of Compression.— This term means that the compressed fuel mixture, or fuel charge, leaks out of the cylinder. Loss of compression results, of course, in loss of power with its attendant waste of fuel. There are three things that cause loss of compression and these are (1) the use of a poor grade of lubricating oil or not enough good oil, (2) piston rings that leak, and (3) valves that leak. The remedy for the first case is obvious, it has been described for the second, and for the third it is to *grind the valves.*

How to Grind the Valves.— If the valves are not ground when they need it the hot exhaust gases will pit them and if this continues for any length of time it will ruin the seats so that it will take a deal of time and trouble to get the valves to properly seat again. The exhaust valves will need grinding at least once a month and the inlet valves once every season.

In L and T head engines it is only necessary to

[1] This is not a universal joint.

take the valve caps off of the cylinder head to get at the valves as shown at *A* in *Fig. 101,* but with a valve-in-the-head engine the head itself has to be unbolted and taken off of the cylinder. In either kind uncouple the valve springs first and then lift the valve from its seat.

Now make a *grinding paste* of a little *No. 120* emery

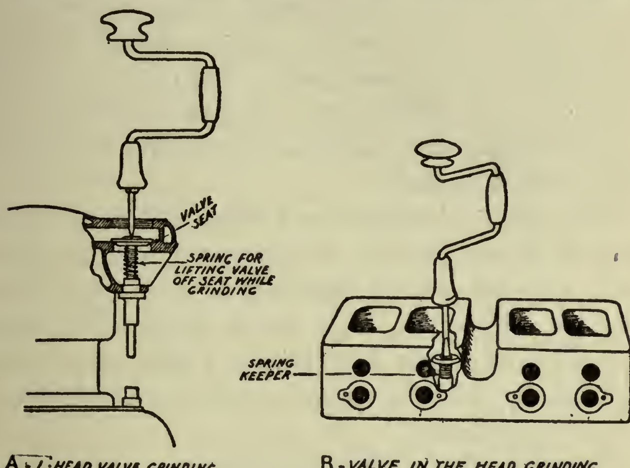


Fig. 101.— Grinding Valves

and a few drops of lubricating oil and thin it down with kerosene.[1] Rub a little of this paste on the beveled edges of both the valve head and the seat and slip a spiral spring over the valve stem to keep it up except when you press down on it. Put a screw driver bit in a carpenter's brace and set the blade of

[1] Or, better, buy the paste ready made.

the bit in the slot of the valve head; press the latter down on its seat and turn it to and fro, holding it down just hard enough to keep it in place.

Look at the valve every little while and see that the paste is evenly distributed over the surface of it. When the valve and its seat show a bright surface, wipe both of them off and mark the beveled edge of the valve head with a soft pencil. Now put the valve back in its seat and turn it to and fro again; if all of the pencil marks rub off it shows that the valve sets in its seat gas tight but if some of the marks remain keep on grinding the valve until the pencil mark test shows that it does seat right.

Replacing a Weak Valve Spring.— When a weak valve spring causes loss of compression put in a new one. You can test the elasticity of a spring by slipping the blade of a screw driver between the turns of it while the engine is running. If the engine picks up it shows that the spring is too weak and that a new one is needed.

Fixing a Few Other Troubles.— (1) Common brown soap will stop gasoline and kerosene leaks for the time being. (2) Chewing gum will stop a water leak, temporarily, if it is not too bad. (3) A small loss of compression can be stopped until you get a chance to put in new rings by using more oil or heavier oil. (4) In driving in a drift-key always allow a 1/32 inch clearance on top or you may split the gear, or wheel, but the key must fit very tight on the sides.

(5) Never run your tractor when the clutch slips as the heat developed will injure the surfaces. It only takes a few minutes to tighten it up but in doing the job be sure to expand both sides alike. And, finally, (6) gears that are correctly designed and which are well made will not vibrate to any extent or make any great amount of noise unless they *bottom,* that is when they mesh too closely. When this is the case the peripheral edges of the teeth of one gear will impinge on the bottom between the teeth of the other gear. When this action takes place you must give them more clearance or it will surely wreck the shafts and bearings. All you need to do to give them clearance is to add shims to the bearings.

CHAPTER XI

TRACTOR REPAIRS AND HOW TO MAKE THEM

THERE are two chief ways in which much time is lost where implements are pulled and machines are driven by tractors and these are (1) when the implement or machine breaks down and (2) when the tractor breaks down. And don't lose sight of the fact that whenever anything happens which stops the work in hand you are paying dearly for it.

How to Prevent Breakage.— The thing to do then is to circumvent all possible delays and the way to do this is to go over the implement or machine and the tractor with due care before you couple them together.

As farm equipment is sent to the various branch houses packed in the safest and most compact manner much of it has to be reassembled after its arrival and this work is often done by men who know more about the selling end than they do about the working end. Hence, what I have said above applies particularly to draw-bar implements and belt machinery.

In going over the outfit you intend using tighten up all the nuts first and be sure not to skip any. It is worse than useless to put a single nut on a bolt on a piece of machinery unless you have a lock-washer under it, and even when a lock-washer or a lock-nut is used the jamb-nut may work off of the bolt and the latter drop out.

I have known of instances, and you probably do too, where a missing bolt shut down the work for an hour or more, nay worse, where it resulted in the actual breaking of a part and laid up the whole outfit for a week or longer. The best way to make a bolt stay put is to use a cotter-pin in the end of it, though this is not always feasible. At any rate, tighten up every nut before you start out and then you will be working on a safe margin and can go ahead with a feeling of security.

How to Repair Broken Parts.— *The Tools You Need.*— Should any minor part get bent, or broken, or lost, you want to be able to repair it, or make a new one, in the shortest possible time. To this end you should get the following assortment of tools, namely, (1) a blacksmith's portable forge with a lever-operated rotary blower; (2) a 50-pound anvil with tools; (3) a fairly heavy blacksmith's vise; (4) a post drill with a chuck that will take twist drills up to ½ an inch; (5) a couple of blacksmith's hammers and a sledge; (6) a pair of long handled tongs and a pair of pincers; (7) a large monkey wrench and a Stilson wrench, and, (8) a couple of rasps.

A kit of machinist's tools will also come in handy and this should include (a) a breast drill with a set of twist drills from ⅛ to ¼ inch for drilling holes in out of the way places; (b) a hack-saw with a dozen blades; (c) a set of taps and dies for cutting screw threads; (d) a pair of tinner's snips; (e) a set of cold chisels; (f) a blow torch; (g) a soldering copper, and finally, (h) a set of wrenches.

The Materials You Need.— A supply of iron bars and rods of different sizes and an assortment of various sized nuts and bolts will be about all the materials you will have to keep on hand.

On Making Emergency Repairs.— When an ordinary part gets lost, bent, or broken, you can easily make a new part, or straighten, or repair, the old part so that it can be used, either temporarily or permanently, with the above tools and materials, then and there. The blacksmith's forge, vise, post-drill and other tools will give you the means for forging parts of considerable size provided they do not require great strength or extreme accuracy.

You will find the machinist's tools useful in fashioning the smaller parts and fitting them in places for which blacksmith's tools are not adapted. With the taps and dies you can cut threads in a piece of metal or on a rod or recut old threads in nuts and on bolts. With the hack-saw you can not only saw off iron bars and rods but you can saw off nuts that are rusted on so tight that you can't start them with either a wrench or by applying the heat of your blow-torch. Finally, with the soldering outfit, you can solder leaks in the radiator, fuel tanks, pipes, etc.

And, right here, a word of warning, to wit, when you are going to solder a gasoline can, or tank, it is not enough to merely empty the fuel out of it, but you must unscrew the filler plug and let it remain exposed to the air for a few hours. Otherwise, when you go to solder it another tractioneer will be needed as well as somebody, like Walt Mason, who can write an epitaph, for gasoline is tremendously explosive when mixed with a large volume of air as against gasoline alone.

Replacing Broken Parts.— All tractors that are made at the present time are built on the *interchangeable plan;* that is, every individual part that is turned out is of exactly the same size, and, hence, it will fit any tractor of the type and size turned out by a given maker.

This being true every tractor maker issues a *Price List of Parts* and be sure that you get your copy when you buy your tractor. This list gives the correct name, number, *cipher word* and price and, usually, a picture of each different part of the tractor, so that when you want to replace a damaged part you can look it up and write or wire for it to the makers' nearest distributor.

In sending by mail for a new part always give the number of your tractor, which you will usually find stamped on the end of the crankshaft or the crankcase of the engine.

In ordering parts by letter you should use the number given in the repair list, and if there is an alphabetic letter preceding, or following, the number don't fail to give it also. In writing it's a good scheme to describe the part as well.

The cipher words given in the list enable you to order easily, cheaply and with certainty by telegraph. In this case use the cipher word only, but you want to be sure to spell it right and then have the telegraph operator spell it out loud to you so that he won't get it wrong. Makers and their distributors ship all parts that are ordered by telegraph by express unless you instruct them otherwise.

Once that you have received the part necessary to make the replacement with it takes but very ordinary mechanical ability to remove the bent or broken part and put the new one in its place for it will fit exactly, or practically so.

Repairing Large Broken Parts.— If some large and costly part of your tractor breaks, as a cylinder, a crankshaft, an axle, etc., you can have it *welded* when it will be just as good as new, and at a cost considerably lower than that of a new part.

There are three welding processes in use and these are (1) the *oxyacetylene* process, (2) the *thermit* process, and (3) the *electric* process. The two former processes are generally used for making welds of broken tractor parts. In the oxyacetylene process *acetylene gas* is burned in a jet of *oxygen* and this makes an intense welding heat.

In the thermit process *aluminum powder* is mixed with *ferric oxide,* when the compound is called *thermit.*

When this is ignited it burns at a temperature high enough to easily melt steel. In the electric process, an electric current is used to raise the heat of the part at the juncture to the welding temperature.

If you will write to the companies named below they will tell you of the shop nearest you which has an outfit and can make the weld. You ought to write now so that you won't have to lose the time when you need the weld made. *The Prest-O-Lite Co.,* 206 Amsterdam Ave.; *The Goldschmidt Thermit Co.,* 120 Broadway, and *The Thompson Electric Welding Co.,* 30 East 42nd St., all of New York City.

On the Removal of Parts.— As the tractors of different makers are of widely different design there is no hard and fast rule that can be given for the removal of different parts from them. For this reason every tractor maker issues an *Instruction Book* and you want to be sure to get your copy when you buy a tractor for it will tell you many things that apply to their make of tractor only.

The *Instruction Book* will tell you how to take out the pistons, the main bevel pinion, the reverse gear, the belt power shaft, the intermediate gear shaft, the main drive pinion, the differential, if your tractor has one, the axle, and a lot of specialized information concerning the particular kind of equipment that is used.

To Take Off a Drive Wheel.— As this is an operation that is often necessary and is common to all tractors, do it this way: Set the jack under the axle and jack it up until the wheel is off of the ground. Then block it up with timbers so that by no possible chance can the jack give way when you start to pry off the wheel.

To Take Off and Put On Cylinders.— When you have to take off or put on a cylinder have enough helpers so that it can be lifted easily and then do the job carefully or you will be apt to injure the piston rings. Further, any false move may result in an accident that will lay up the tractor for such time as it takes to get a new cylinder and will cost you all kinds of money for the replacement, besides the worry that always goes with such untoward happenings. In taking off a cylinder have all the compression cocks open or you are likely to have more help than you bargained for.

Regrinding Old Cylinders and Sleeves.— As I mentioned way over there in the third chapter some cylinders are formed of (1) solid blocks of iron bored out, and that the better ones have (2) sleeves fitted into them, so that they can be removed easily. In either kind the cylinder walls may become either (*A*) *scored,* that is scratched by the road dust and carbon particles deposited in the cylinder or by a broken piston ring, or (*B*) for the hole to be worn out of true by the angular pressure of the piston on its down stroke.

Now there are three ways to true up the hole of a cylinder and these are (a) by *grinding* it out, (b) by *reaming* it out, and (c) by *boring* it out. Grinding is the most successful way for it generates the hole true with the face of the cylinder, the bore is made round and the walls straight. The grinding wheel is not affected by oil, or by the hard or soft spots in the iron, while reamers and boring tools are affected more or less by these conditions. *The Butler Manufacturing Co.,* of 1120 East Georgia Street, Indianapolis, Ind., will give you prices on regrinding the cylinders of your engine.

CHAPTER XII

THE KIND OF TRACTOR YOU WANT

When you have made up your mind to part with your good money and accept in lieu thereof a tractor you want to go into the deal with your eyes open. And just remember it isn't what the *salesman says* but what *you know* that counts.

Now in buying a tractor I may be of some small service to you, in a silent way, to be sure, but none the less a potential agent, who offers you unprejudiced advice for I am in the automotive business but not in the employ of any engine builder or tractor maker, and hence I stand for the interest of the consumer only.

The Field to Choose From.— As you have seen in going over this book there are nearly two hundred and fifty different makes of tractors and a dozen different sizes for you to choose from and, there's the rub, for the field is so large that it would take the average prospective buyer the best part of a winter to sift the literature relating to all of them, make a comparison of their merits and demerits and then select the one that seemed to come the closest to fulfilling the required specifications.

To save you all of this bother and loss of time I have tried to correlate my researches and epitomize my conclusions concerning tractors in a broad and understandable way in this final chapter and I hope that they will (1) enable you to get the best tractor made for the amount of money you want to spend, and (2) induce the tractor makers to make even better tractors than they are making to-day.

Kinds of Tractors.— Structurally, there are only three kinds of tractors and these are (1) real tractors, (2) makeshift tractors, and (3) homemade tractors. The only kind of tractors I have explained in this book are *real pedigreed* tractors, by which I mean tractors that are the result of experimental and practical work from the beginning of the tractor industry and which are designed by high grade engineers and built by skilled workmen in up to date factories equipped with modern machinery.

What I call *makeshift* tractors are those that are made out of motor cars, either new or used, either by reconstructing them or by fitting them with tractor drive wheels and other tractor parts. Motor cars are designed for speed and are built altogether too light for draw-bar and belt work even though they are fitted with proper reduction gears, nor are they sufficiently protected against the dust for field work.

Finally, no farmer would attempt to built a tractor in this enlightened day of precision measurements, high speed steels and quantity production unless he is making a strenuous bid for internment in a psychopathic ward.

What to Pay for a Tractor.— About the first thing a man wants to know when he gets the idea of buying a tractor is what one will cost him, for on its initial cost as well as on its upkeep will depend its value to him as a power producer for his farm.

From the prices given in this book you will have observed that various sums are quoted for tractors having the same horse power and this is due to differences in (1) the design and construction of them; (2) the materials used in them; (3) the shop methods employed in making them, and (4) the way in which they are sold.

Your chief concern, though, is in the design and construction of the tractor itself and the materials used in it for these are the big things. So, whatever you do, don't buy a tractor because it is cheap, for it stands to reason that a low-priced tractor can't be built as well, or of as good materials, as one that costs more money and the best is none too good for you. Still, as a matter of farm economy, you don't want to cut into your working capital too heavily.

Hence, you must estimate (*a*) the amount of work the tractor will do in a year; (*b*) the value of the work it will do; (*c*) the value of the horses it will take the place of; (*d*) the value of the men's work it will do in their place, and (*e*) the additional profits which you believe will accrue to you by using it. These figures will then give you a rough idea of the amount you ought to spend for a tractor.

As to actual prices, $1,000 is enough to pay for a good 2-plow tractor; $1,400 for a 3-plow tractor, and $2,000 for a 4-plow tractor, while the plows that go with them sell for about $150, $200 and $260, according to the number of bottoms they have.

Getting a Tractor of the Right Size.— In the chapters over toward the front I explained all about the size of the tractor you need for farms of different acreages and which I based on the number of plows the various tractors are recommended to pull and the belt horse power they are rated to develop.

Now, right here, I want to emphasize the importance of getting the *right size* tractor for your farm. If you buy one that does not develop enough power to do the draw-bar or belt work required of it, you will either have (1) to sell it and buy a new one; (2) trade it in for a larger one, or (3) hire a more powerful one to do the work, and you will find any of these transactions a losing deal.

Contrariwise, if you buy a tractor that develops more power than you need you cannot handle it to as good an advantage and, what is more to the point, its cost of operation and maintenance will be increased. A tractor of the right size is the only one you can afford to buy if you are farming for profit.

The Five Prime Factors.— Knowing now the price you want to pay and the size of the tractor you need the next thing to consider is the general construction of the tractors you intend to choose from.

There are five *prime factors* in the makeup of a good tractor and these are whether (1) it is built on the *interchangeable plan,* (2) it is of *substantial construction,* (3) its parts are made of the *best kind of steel, properly treated,* (4) it is fitted with *ball and roller bearings,* and (5) if all of the working parts are *entirely enclosed.* If you can buy a tractor that includes all of these good features, by all means do so and you will get the full value of your purchase price.

The Interchangeable Plan.— As far as I know all tractors are built on the *interchangeable parts plan,* that is, every like part of a given type and size of a maker's tractor will fit any other tractor of like type and size made by the same maker. If there are any tractors on the market that are not built on the interchangeable plan my advice to you is to keep away from them.

Substantial Construction.— While you do not want a tractor that is too heavy you certainly do not want one that is built too light. You don't have to be a mechanical engineer to tell by looking at a tractor whether its general construction is heavy enough for field work and don't buy one if, in your opinion, it is not built strong enough to stand up under the work.

The Kind of Steels Used.— To hold together under the wear and tear a tractor is subjected to the frame should be made of steel and if it is of the built up type be sure it is hot riveted. Don't buy a tractor with a cast iron frame. The front axle should be made of *drop forged* steel and the rear axle of *chrome-nickel* steel, though *high-grade, open-hearth* steel is generally used for these parts.

The shafts of the transmission system should be of *chrome-nickel,* or *manganese* steel, while the gears of the transmission should be of *chrome-nickel* steel, *heat treated* and not *case hardened.* *Crucible* steel is largely used for making cheap gears. Don't buy a tractor with *cast* gears and, whatever kind you get, be sure the gears are *machined.*

Don't let any salesman tell you that steels of any other kind than those I have cited as *best,* are "just as good" for he either doesn't know or else he is trying to put one over on you.

Ball and Roller Bearings.— Every bearing in the transmission system, the front and rear wheels and the fan, should have either *ball* or *roller bearings.* Ball bearings are the best where there is no great load upon them for they run with less friction, but roller bearings are the best where the load upon them is heavy for while there is a little more friction they stand up better. In any event, see to it that the axles and every shaft has a ball or roller bearing and I wouldn't take a tractor with *plain* bearings.

All Enclosed Mechanism.— Of as much, or more, importance than the above enumerated factors is this last one of having all the working parts enclosed. If I was in the market to-day for a tractor I wouldn't, under any circumstances, buy one in which any of the working parts from the engine to the final drive were exposed.

It's the dust and the dirt that grinds the life out of the bearings of a tractor and the better the mechanism is enclosed, all other factors being equal, the fewer stops you will have to make, the lower will be your repair costs and the longer your tractor will last.

The Wheel vs. the Crawler.— There is not a great deal of choice between these two types of tractors except where soil conditions make the crawler preferable. In the wheel type, however, there is less friction.

The Wheel Tractor.— Nearly all wheel tractors are made with four wheels and, therefore, we must assume, that the majority of engineers who design tractors, believe that the four wheel type with the three-point suspension is better adapted for tractor work than the three wheel tractor, just as four wheels have long ago been considered more serviceable for all kinds of horse-drawn and motor vehicles.

While a single drivewheel makes a differential unnecessary, a pair of drive wheels is more efficient since they have a larger surface area and hence they make better contact with the soil. In some tractors a drum is used which does away with the differential and at the same time it offers as much or more contact surface than a pair of wheels.

Large drive wheels are better than small ones for they not only provide a larger contact area, and, hence, have more traction resistance than wheels of smaller diameter, but they make the tractor ride over rough ground easier. The latter is also true regarding a long wheel-base of a tractor, namely, it will travel over rough ground with less jarring motion than one with a short wheel-base.

The Crawler Tractor.— Of course, you know how the *tanks* in France made their way through mud, went through sand, moved over rough roads and crawled over trenches where any kind of a wheel vehicle could not have gone. Well, the crawler type of tractor was the model used upon which the tank was designed.

The jointed tracks of the crawler tractors go over the uneven ground by traveling over a smooth steel roadway of its own making.

The crawler type of tractor has many times the number of square inches of surface contact with the ground possessed by the wheel tractor and, hence, where the latter tends to pack the soil, by virtue of the weight of the tractor resting on this small surface area, the weight of the crawler is distributed over a large surface area in about the proportion of about 40 to 90 pounds per square inch in the wheel tractor as against about 6 pounds per square inch in the crawler. In other words if your farm is soft, rough or hilly a crawler tractor will serve you better than a wheel tractor.

The Differences in Engines.— *The Number of Cylinders.*— A *four cylinder* engine is better than a *two cylinder* engine because in the former the power stroke takes place twice during every revolution of the crankshaft, whereas, in the latter the power stroke takes place only once in every revolution. For tractors I do not consider a *six* or an *eight* cylinder engine any better than one with only *four* cylinders except where more power is needed.

The Horizontal versus the Vertical Engine.— There is no reason why a horizontal engine is not just as good as a vertical engine for tractors except that it is, perhaps, a little harder to lubricate. The fact remains, however, that all motor cars and motor trucks are powered with vertical engines and nearly all tractors are similarly equipped; that this, then, will be the standard practice in the course of time there is very little doubt.

Solid Cylinders versus Sleeve Cylinders.— The scheme of using a removable sleeve in the cylinder is what I should call a great improvement in engine building and both horizontal and vertical engines are built with them. The ease with which a sleeve can be removed, reground, and replaced, or a new one put in and its low cost, makes it worthy of your consideration.

L, T and Valve-in-the-Head Engines.— Where L and T head engines are used the heads are seldom removable and you can get at the valves to regrind them with very little trouble. But the consensus of engineering opinion is that the valve-in-the-head type is more efficient because there are no side pockets or valve chambers and. consequently, the full force of the explosions act directly on the piston head instead of part of it being dissipated in these out of the way places.

Position of the Engine on the Tractor.— In some tractors the engine sets with its crankshaft parallel with the length of the frame and in others it sets horizontally. When in this latter position it eliminates the bevel gears that are necessary to turn the power at right angles. While the former method reduces the number of gears necessary and uses spur-gears only, bevel gears are just as efficient as power producers and there is no objection to their use.

Splash and Force Feed Lubrication.— An engine that has a splash or a circulating force feed system of lubrication will give you very satisfactory service but one that is fitted with an individual pump positive oil feed is better and it also adds to the cost of the tractor. I consider the latter a necessary adjunct to every large tractor.

Radiators and the Water Cooling Systems.— Radiators should by all means be made of copper and for tractor engines I prefer the tubular type, also the pump circulating system rather than the thermo-syphon system, and fan cooling instead of using the exhaust of the engine for this purpose.

The Matter of Fuels.— Various makes of tractor engines of the same rated horse power use different amounts of fuel per horse power but as the difference is practically a negligible quantity, you don't need to pay any attention to it.

Gasoline is the better fuel for tractor engines as it vaporizes easier, is less apt to produce carbon, makes the engine run smoother and is not as likely to give trouble as kerosene. *Kerosene,* on the other hand, only costs about half as much as gasoline and it is a very satisfactory fuel when used in engines that are built to run on it.

When *water* is injected with the kerosene into the cylinders it helps to convert the fuel into gas and to remove the carbon, but these good features are counterbalanced by the water leaving a lime deposit in the cylinders and it has, besides, a very bad effect on the pistons and cylinder walls.

Don't buy a tractor unless the carburetor is provided with an *air cleaner.* Nearly all tractor makers use the dry air cleaner in preference to the water air cleaner because the former is smaller and is less troublesome.

The Ignition System You Want.— When you buy a tractor be sure the engine is equipped with the *magneto ignition* system, and by all means get one that has an *impulse starter.* A magneto system requires practically no care, whereas with a *storage battery and circuit breaker* system you are up against the proposition of keeping it on your mind even when you are asleep.

Engine Governors.— While centrifugal governors are the most widely used the newer kinds are all right, too. Don't invest in a tractor without a governor and don't take one where the governor is exposed to the dust.

The Power Take Off.— Some tractors are made with the power take off pulley mounted in front, or in the rear on a shaft that runs parallel with the length of the frame. The trouble with this kind of a power take off is that it is so all-fired hard to get the tractor pulley in alignment with the machine pulley and then to take up the slack in the belt for you can't back into it. Where the pulley is on the side of the tractor backing into the belt is an easy matter.

Accept the Transmission System.— When you can satisfy yourself on all of the foregoing recommendations I have made accept whatever kind of a clutch, transmission, differential and final drive the tractor may have for you can depend on it the makers have put in the best transmission system they could according to their light.

It is a good plan to get a tractor with a transmission that has two or more speeds forward for this will enable you to change the speed of your tractor within certain limits without changing the adjustment of the governor. Whether there is a differential doesn't matter, but the matter of the final drive is important and as to the kind to be used there is wide difference of opinion, though personally I like the worm-gear drive the best.

The Steering Gear and Brakes.— A steering gear with a worm and nut movement and a knuckle axle is by all odds the easiest to handle. Every tractor should have two *brakes,* one on the transmission shaft, to keep it from spinning, and the other an emergency brake, and don't take a tractor unless it is so equipped.

The Firms Back of the Tractors.— As a last word you want to give due consideration to whether the maker of the tractor which you are thinking of buying (the tractor I mean) is going to be in the business the next year, or will be like dozens of other tractor manufacturers *i.e.,* cash in his chips prematurely.

Your sole interest in his longevity lays in the fact that if he makes his exeunt through the little green door of bankruptcy you will probably not be able to get replacements at all. Further, the larger and older a concern is the more distributors it is likely to have, which means that there will be one within easy reach of you, and, finally, the latter will always have on hand a full stock of replacement parts.

These are vital elements in keeping your tractor going day after day, week in and week out and it is only when you can use it continuously and with certainty that you can make a success of farming with it.

APPENDIX I

How to Find the Horse Power of a Tractor Engine.— The way to find the horse power of an internal combustion engine of any kind whether it has vertical or horizontal cylinders and no matter what kind of fuel it uses is easily done by using the following formulae:

For a Four Stroke Cycle Engine.

$$H.\ P. = \frac{D^2 \times N}{2.5}$$

where H. P. is the horse power of the engine and is what you want to find,

D^2 is the diameter of the bore of the cylinder and this you square,

N is the number of cylinders, and 2.5 is a constant.

For a Two Stroke Cycle Engine.

$$H.\ P. = \frac{D^2 \times N}{1.5}$$

The symbols in this formula represent the same quantities as those given for the four stroke cycle engine.

APPENDIX II

How to Find the Belt Horse Power of a Tractor Engine.— The following formula for figuring the belt horse power of a tractor engine has been adopted by the *Society of Automotive Engineers*.

$$\text{Belt H. P.} = \frac{D^2 \times L \times A \times N}{14.000}$$

where Belt H. P. is the tractor engine belt horse power and is what you want to find,

D^2 is the diameter of the engine cylinder squared,

L is the length of the stroke in inches,

A is the revolutions per minute of the engine,

N is the number of cylinders, and 14,000 is a constant.

This formula will give the belt horse power of the engine very closely but to find out the belt horse power accurately you must use a *dynamometer*. (See page 3.)

APPENDIX III

The Draw Bar Pull of a Tractor at Various Rates of Speed

DRAW BAR HORSE POWER OF TRACTOR

Miles per hour	Pull in Pounds								
	8 H.P.	10 H.P.	12 H.P.	15 H.P.	18 H.P.	20 H.P.	25 H.P.	30 H.P.	40 H.P.
1.00	3,000	3,750	4,500	5,620	6,750	7,500	9,360	11,250	15,000
1.25	2,400	3,000	3,600	4,500	5,400	6,000	7,500	9,000	12,000
1.50	2,000	2,500	3,000	3,750	4,500	5,000	6,250	7,500	10,000
1.75	1,710	2,150	2,580	3,200	3,860	4,300	5,360	6,450	8,600
2.00	1,500	1,880	2,230	2,820	3,390	3,760	4,700	5,650	7,500
2.25	1,335	1,670	2,000	2,500	3,000	3,340	4,180	5,000	6,700
2.50	1,200	1,500	1,800	2,250	2,700	3,000	3,750	4,500	6,000
2.75	1,090	1,360	1,630	2,040	2,450	2,720	3,400	4,080	5,450
3,00	1,000	1,250	1,500	1,875	2,250	2,500	3,125	3,750	5,000
3.25	920	1,150	1,385	1,730	2,040	2,310	2,880	3,460	4,620
3.50	850	1,070	1,285	1,610	1,930	2,140	2,680	3,220	4,280

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