POWER FROM YOUR TRACTOR

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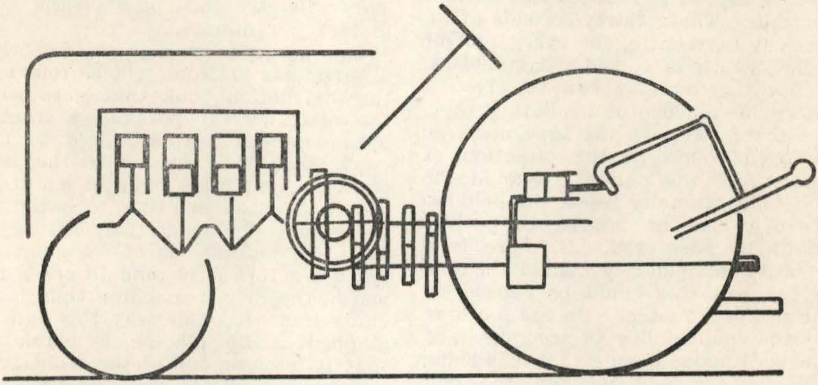

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IN BULLETINS No. 240 and No. 246 of this series it was pointed out that power can be delivered from a modern tractor engine in four ways — the belt pulley — the power take-off — the hydraulic mechanism — and the drawbar. The power output of an engine is measured in terms of horsepower, one horsepower being equivalent to 33,000 ft. pounds of work per minute. This bulletin deals with the use of power at each of the four points mentioned above.

The maximum available horsepower of an engine is obtained at the flywheel. In a tractor, however, some internal mechanism must be driven before the engine power can be used, and this results in a certain amount of loss. For example few current tractors are designed with the belt pulley directly driven from the flywheel. Power is absorbed in overcoming friction between turning gears and between bearing surfaces and in the churning of oil before it is finally delivered to the belt. Even then some power loss occurs in the work done in flexing the belt around the pulleys and of course in the slipping of the belt But the greatest power loss in tractors occurs between the flywneel and the drawbar, due largely to the extended power train and to drive wheel slip. Improved designs and better materials have reduced these transmission losses considerably.

Tractor specifications generally refer to the power available at the belt pulley and the drawbar, and the figures quoted represent the amount of power that is available for use.

The Belt Pulley:

When referring to the belt pulley, it is usual to state the maximum belt horsepower together with the revolutions and the size of the pulley. The speed of the belt in feet per minute is sometimes given also. The revolutions of the belt pulley are generally slightly less than the revolutions of the engine crankshaft. The diameter of the pulley is such that, when the engine runs at its rated speed, the speed of the belt is round about 3,100 ft. per minute. The speed at which the driven machine will run is determined by the size of its own pulley.

Belt drives should provide a trouble free and a safe means of transmitting power. Some of the important points in relations to belt drives are as follows. The type and size of belt, the tension on the belt, the arc of contact between the pulley and the belt, the belt fastening and the diameter of the pulleys. Correctly applied belts should have little slip. Should a belt slip it is probably too slack, too smooth, or there may be liquid on the belt. Flapping and surging indicate a badly made belt, a belt poorly fastened, one too light for the load, or wobbling, or unevenly faced pulleys. When making a new belt it is very important indeed that the ends should be cut square.

Most high speed pulleys are crowned. Too much crown will cause the belt to slip as it reduces the contact surfaces. Three thirty-seconds of an inch, at the centre, for every foot of pulley width is considered sufficient. A flat faced pulley can be given a crown by the use of insulating tape, but to be effective the tape must be wrapped round in the direction of rotation of the pulleys. Should the pulleys continually reject the belt too great a load or misaligned pulleys might be suspected. If there is a fracture immediately behind the join in the belt this could be caused by the use of a fastener that is too long for the small pulley to accommodate. The continuous flexing that it is being subjected to will weaken the belt behind the fastener. For this reason the type of fastener must be governed by the diameter of the small pulley.

A simple drive reduces wear on the belt to a minimum. Pulleys with flanges as well as guide pulleys will increase belt wear as will the use of a crossed belt in order to produce a drive in the opposite direction. For running crossed, thick narrow belts are best able to withstand the wear caused by one belt crossing the other, but for running straight, thin and wide belts give the best results. If the circumstances permit, the drive should be arranged with the slack side of the belt uppermost. This will increase the arc of contact between the pulleys and the belt. On the driver pulley the belt is constantly slipping from a slack to a tense state. The reverse happens on the driven pulley. This gives rise to a slow creeping of the belt which creates a shiny surface on it and on the pulley. A well made belt, however, if kept clean, should not cause undue loss through slipping. To offset this effect textile belts should be reconditioned periodically with castor oil and leather belts with curriers dubbin. For agricultural use, textile belts are better due to the fact that leather belts are susceptible to wetting and are more expensive.

To calculate the pulley size necessary to drive a machine at a given speed the following formula is used:

$$\frac{\text{Speed of follower}}{\text{Speed of driver}} = \frac{\text{Radius of driver}}{\text{Radius of follower.}}$$

The nearest size to the calculated size in full inches will have to be chosen. When ordering a belt it may be necessary to know the speed at which the belt is going to operate. This can be found by multiplying the pulley diameter in feet by 3-1/7th and the result by the number of revolutions per minute of the pulley. This will give the speed of the belt in feet per minute.

The horsepower required to drive a particular machine will be found in the instruction book that goes with the machine. If possible a tractor with a power output suited to the work should be used. If the belt work is light the radiator shutters should be used in order to maintain the engine operating temperature at its most suitable level. Pneumatic tyred tractors may tend to creep towards the driven machine thus loosening the belt. One way this can be stopped is by placing a plank so that it rests on top of the front tyre and wedges itself underneath the tractor rear tyre.

The importance of standing clear of a fast moving belt cannot be overstressed. Wearers of loose clothing should be particularly careful in this connexion. It is good practice to ground a rubber tyred tractor by means of a chain or a wire so as to provide an outlet for static electricity generated through the action of the belt.

The Power Take-off:

Introduced about 1925 the idea of a power take-off has allowed designers to lighten the construction of machines formerly driven from the ground. The internal mechanism can also be driven at a speed independent of the forward speed of the machine. It must be realised, however, that a power take-off operated machine demands two power contributions from the tractor engine. One to pull the machine and one to drive the internal mechanism. According to a recent English publication from the N.I.A.E. a pull of approximately 400 pounds is needed at the drawbar for every ton that a machine weighs. In hilly country at least one-quarter again can be added. Power for driving the internal mechanism varies from between one-third of a horsepower per foot of cutter bar on a mower and one horsepower per foot of cutter bar on a header. For example, if a machine weighed a ton a pull of approximately 400 pounds is needed to draw it along on the flat. If this pull is kept up at a constant forward speed of three miles an hour the drawbar horsepower needed would be:

$$\frac{3 \times 400}{375} = 3.2.$$

Similarly, to pull a machine weighing two tons, on hilly land, at three miles per hour would need a drawbar horsepower of approximately:

$$\frac{3 \times 800, \text{ plus } 200}{375} = 7 \text{ approx.}$$

Suppose the machine had a six foot cut, the power needed to drive the internal mechanism would then be 6 h.p.—if the machine were a header. The total horsepower needed would therefore be 15 drawbar horsepower approximately.

The telescopic power take-off shaft of a machine incorporates two universal joints. This allows for a certain amount of movement. In actual fact the maximum angle of drive for a double universal joint is 22 degrees. In practice it is best to limit the angle to about 15 degrees either with stops to prevent too great a lock being used or else by disengaging the power take-off shaft clutch when turning. To share the angular movement equally the hitch point should be half way between the knuckle joints. The shaft should be assembled with the half knuckles of the two joints in the same plane. Care should be taken to make sure that the power take-off connexion from the machine is securely clamped to the tractor power take-off shaft splines. The adjustments generally found on power take-off driven machines should be used to make sure the drive shaft is as straight as possible.

Safety clutches are provided on all power take-off shaft drives. They should never be allowed to become rusted up through neglect. To set them, loosen the tightening bolt, put the machine to work under normal conditions, and then tighten the bolt on the safety clutch just enough to allow the machine to work without the clutch slipping. The revolving power take-off shaft is a menace if left unshielded. Loose clothing can readily be picked up and once wrapped round the revolving shaft it cannot be freed and will drag the operator towards the shaft. Avoid a serious accident by keeping the guards always in position when working.

The Hydraulic Mechanism:

Normally the hydraulic mechanism has a specific job to do,—to raise the implements. In certain cases the hydraulic mechanism is used for depth control. Essentially the system consists of a pump, a ram and a means of control. The pump is generally a multicylinder or a gear type and is driven from the transmission system. The ram is generally built into the rear of the tractor under the seat and operates a cross shaft which raises the lift arms. The control mechanism naturally, depends on what it is desired should be done.

The system has for its primary function the lifting of implements that are mounted on the tractor. Where arrangements have been made for the tapping of the system to take oil to remote cylinders the range of application is increased. A remote cylinder can be used for raising ploughs, cutter bars of headers, bulldozer blades and so on. The use of one line from the pump will push the ram outwards in the cylinder. The use of two lines is better if complete control is to be provided. Before making use of the hydraulic system in this way it is essential to check the pressure that can be developed to make sure it is sufficient to do what is intended. High pressure hose would have to be used and a means of sealing the ends worked out, to prevent loss of oil and the entry of dirt when disconnecting the hose from an implement.

The Drawbar:

In tractor specifications, when referring to the drawbar, it is usual to give the maximum available pull in various gears. The drawbar horsepower may also be given. A misleading conception can be conveyed if only the drawbar horsepower is quoted. This is calculated from readings taken of the sustained pull and forward speed over a given distance. A large pull and a slow forward speed will give the same calculated result as a small pull and a fast forward speed. For this reason the horsepower, as well as the pull and forward speed at which it was calculated, are always given—at least in official tractor tests.

For reasons explained in Bulletins No. 240 and 246 the maximum drawbar pull obtained under test conditions may not be reached under farm conditions. Wheel slip will be the most likely limiting factor with wheel tractors. For this reason, on some soils, and where slopes have to be negotiated, half track equipment, wheel grips, or two sets of rear wheels—one set being of steel—may be the solution to obtaining the maximum output from the tractor drawbar all the year round. Wheel weights, or the use of water ballast, are other practical methods for adjusting the rear wheel weight to suit the job in hand. Alternatively every effort should be made to do the job when the soil and weather conditions are right.

To do the maximum amount of work in a given time, and to use the least amount of fuel in doing it, correct loading is essential. The only way to be certain of this is through the use of a dynamometer which records the pull being exerted. The maximum figures recorded under test will then indicate how much more can be pulled. This is hardly a practical method, commonsense however will tell much. Listening to the note of the engine and trying different gear and governor settings will indicate what reserve of power is available. By using different gear ratios, different throttle settings, and by altering the effective width of the implements a good deal can be done to load the tractor engine as fully as commonsense indicates.

When loading a tractor at the drawbar up to somewhere near its capacity the amount of wheel slip—the most subtle of power losses—should not pass unnoticed. The simplest way to check on this is to get off the tractor and examine the tracks the wheels have made. In particular the tracks of rubber tyres on grassland can easily convey a false impresion unless examined closely. A good deal of wheel slip can occur without it being obvious.

Overloading however should be avoided. Apart from reasons of wear and tear a reserve of power is essential in order to deal with more difficult conditions. For this reason 85% of the maximum drawbar pull is taken as the working pull available. The following table from an American publication gives the approximate resistance per square inch of different types of land. As soil conditions differ considerably these figures can only be taken as a rough guide:

Light land 4-6 lb per sq. inch.
Medium land 6-9 lb per sq. inch.
Heavy land 9-13 lb per sq. inch.
Very heavy land 13-18 lb per sq. inch.

For example suppose the maximum drawbar pull of a tractor in ploughing gear (most usually second) were 2,500 lb the maximum furrow slice were 10 x 6 inches and the estimated land resistance from the above table were 10 lb then the draught per furrow would be 10 x 6 x 10 = 600 lb. The working drawbar pull is 85% of the maximum that is

$$\frac{2{,}500 \times 85}{100} = 2{,}125 \text{ lb.}$$

The number of furrows would therefore be

$$\frac{2{,}125}{600} = 3 \text{ furrows.}$$

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