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Basic Hydraulics ME 223

Final Project

OBJECTIVE

The objective of this project is to demonstrate how the hydraulic system for the three point lift system (also known as a "3-pt hitch") works on an 8N Ford tractor. The 8N model is a utility tractor and was manufactured from 1947 through 1952, and many are still in operation today. At the time of manufacture, this hydraulic system was a fairly new design. Today, it is the primary method of attaching implements to utility tractors. The system will be demonstrated through discussion, schematics, pictures, and calculations necessary to fully describe the internal operation, speed, and lift capabilities of the system.

SUMMARY

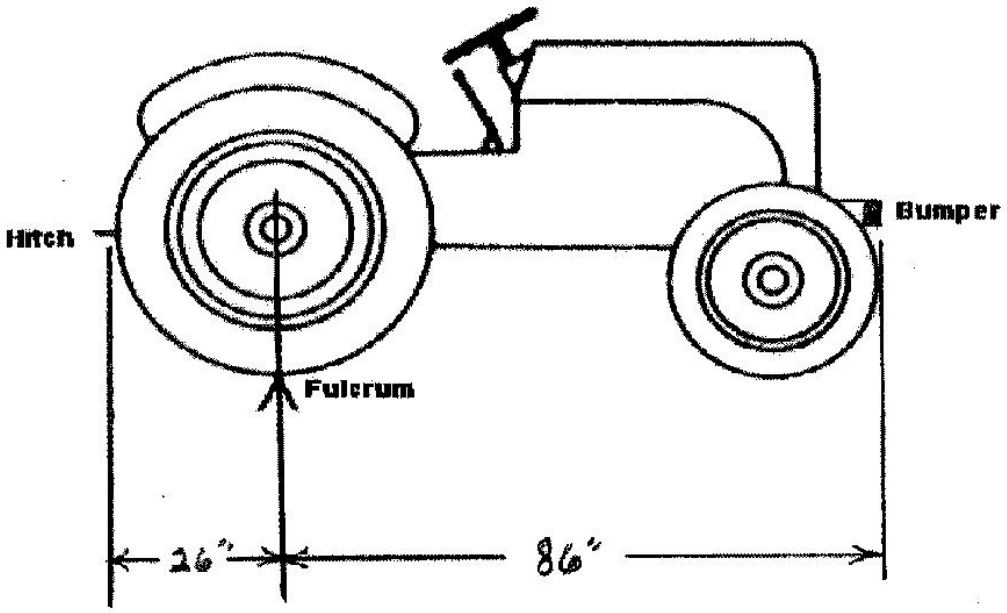
The 3-pt hitch system on the 8N tractor is capable of lifting 800 pounds in the standard configuration. This is accomplished by a combination of hydraulic force of 736 pounds, combined with mechanical leverage equivalent to 64 pounds. The hydraulic force is derived from a system that delivers 1500 psi and 2.15 gpm of fluid flow in combination with a ram (piston diameter: 2.5 inches; travel length: 8.5 inches).

When this hydraulic system is coupled with a mechanical lever system, the working height of above-ground implements can be automatically controlled during the transportation and operation. This system is also able to maintain automatic or constant draft control for below-ground implement use. The combination of the lifting force and automatic control is one of the reasons this hydraulic system is still in use more than 60 years after it was developed.

DISCUSSION

Figure 1 contains a diagram of the 8N Ford tractor, indicating the "load" position where implements are attached.

Figure 1. 8N Ford Tractor



The purpose of the 3-pt hitch system on the 8N Ford tractor is to raise implements above ground level for transport (transportation mode) and maintain depth of cut and wheel traction when implements are in use (draft mode). A rotary mower (brush hog), which is intended to be used above ground level, requires only position control to maintain a constant working height while in use. On the other hand, a plow, which is designed to work below ground level, requires both position control for transport and draft control for plowing. When an implement used below ground encounters increased resistance from different soil types, such as clay, or tree roots, it becomes harder to pull, requiring more power from the machinery and increased traction from the tires to the ground. Since the available horsepower and level of traction cannot be increased, the hydraulic system is designed to raise the implement, thus reducing resistance, until the power and traction are again sufficient for forward movement, and then the system adjusts the implement height again to the former level.

The 8N hydraulic system consists of the following components:

- an internal piston pump;
- a lift cover which contains the lift cylinder (ram);
- several valves: control valves, pressure relief valve, check valve, back pressure valve, and safety valve; and
- a selector lever that mechanically determines draft mode or transportation mode.

A mechanical linkage system consisting of levers, a piston rod, cam, two lift arms, a control spring and 3-pt connections are also utilized in this system. Figures 2 and 3 depict the hydraulic control and constant draft control of this system. Figure 4 contains a schematic of the hydraulic components in this system.

Figure 2. Hydraulic Control System of 3-Pt Hitch

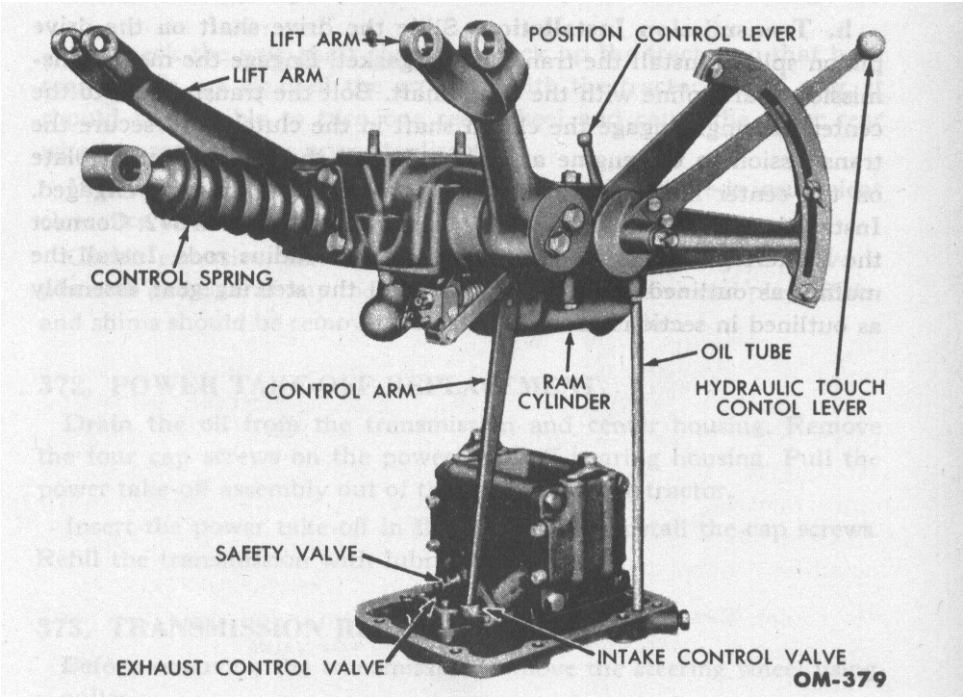
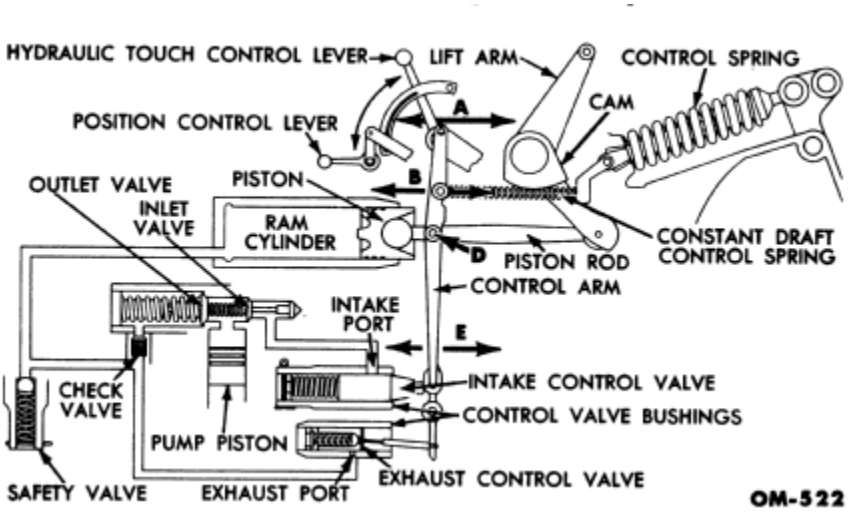


Figure 3. Diagram of Draft Control of the 3-Pt Hitch System



Transportation Mode

Lift Position

When the position control selector lever (Figure 2) is moved to the transportation position and the hydraulic touch control lever is moved to the raised position (Figure 2), the intake control valve opens. If the pump piston is on the suction stroke, oil flows from the reservoir through the intake ports and inlet valve into the pump. As the pump piston rises to the top of its bore, it blocks off the intake ports and forces the oil in the cylinder through the outlet valve and check valve and into the ram (lift cylinder). The piston then returns to the bottom of the cylinder, closing the outlet valve, creating suction that again draws fluid into the pump cylinder. This process is continued until the ram cylinder is full or the hydraulic touch control lever is moved from the lift position.

When the ram cylinder is full of fluid and the ram piston is extended to its maximum travel position and the hydraulic touch control lever is in the raised position, the pressure in the system is sufficient to pass through the safety valve, allowing fluid to flow back to the reservoir. This prevents excessive wear on the pump and reduces friction and thus fluid temperature.

Lowered Position

When the hydraulic touch control lever is moved to the lowered position, the exhaust control valve opens, allowing fluid to flow from the ram cylinder back into the reservoir.

Neutral Position

When the hydraulic touch control lever is moved to the neutral position, both the inlet and exhaust valves close, which causes oil to be trapped in the ram cylinder, maintaining ram position and implement height. Oil is recirculated into the reservoir, bypassing the ram cylinder, which prevents the fluid from heating up due to friction and prevents unnecessary strain on the pump

Draft mode

When the position control lever (Figure 3) is moved to the draft position and the hydraulic touch control lever is placed in the forward position, the hydraulic valves are moved to the exhaust position, allowing the implement to lower to the ground. As the implement encounters resistance, the control spring compresses, allowing the mechanical control arm (item D in Figure 3) to move the intake control valve, allowing fluid to flow to the ram cylinder, causing the ram to lift the implement. When the implement is raised sufficiently to reduce resistance between the implement (plow) and the ground, tension on the control spring is released. This allows the control valve to move to the exhaust position and the ram cylinder will exhaust fluid back to the reservoir, which lowers the plow to back to the ground.

When an implement is raised with the 3-pt system, the tractor's rear wheels act as a fulcrum point (see Figure 1). With calculations not described here, it can be calculated that approximately 800 pounds on the lift system will cause the load (see Figure 1) to work as a lever on a fulcrum point and raise the front wheels off the ground. This means the maximum lift capability should be just under 800 pounds of lifting force.

The pump and cylinder specifications on this system are as follows,

- Pump pressure = 1500 psi
- Pump flow rate = 2.15 gpm

- Cylinder piston diameter = 2.5 inches
- Cylinder piston area = 4.91 inches^2
- Cylinder Bore Length (piston travel) = 8.5 inches

To calculate the lifting force available, the following formula is used:

Force = (Pressure) x (Area)

Force =(1500psi) x (4.91in2) = 737 pounds

This amount is increased slightly by mechanical leverage in the lift arms, bringing the available lifting force to approximately 800 pounds.

The time it takes to lift the implement should also be taken into consideration. If an implement is raised too quickly, it could cause sudden and unexpected handling conditions of the tractor or over-correction of the working height of the implement. To calculate the time it will take to raise the implement we use the formula:

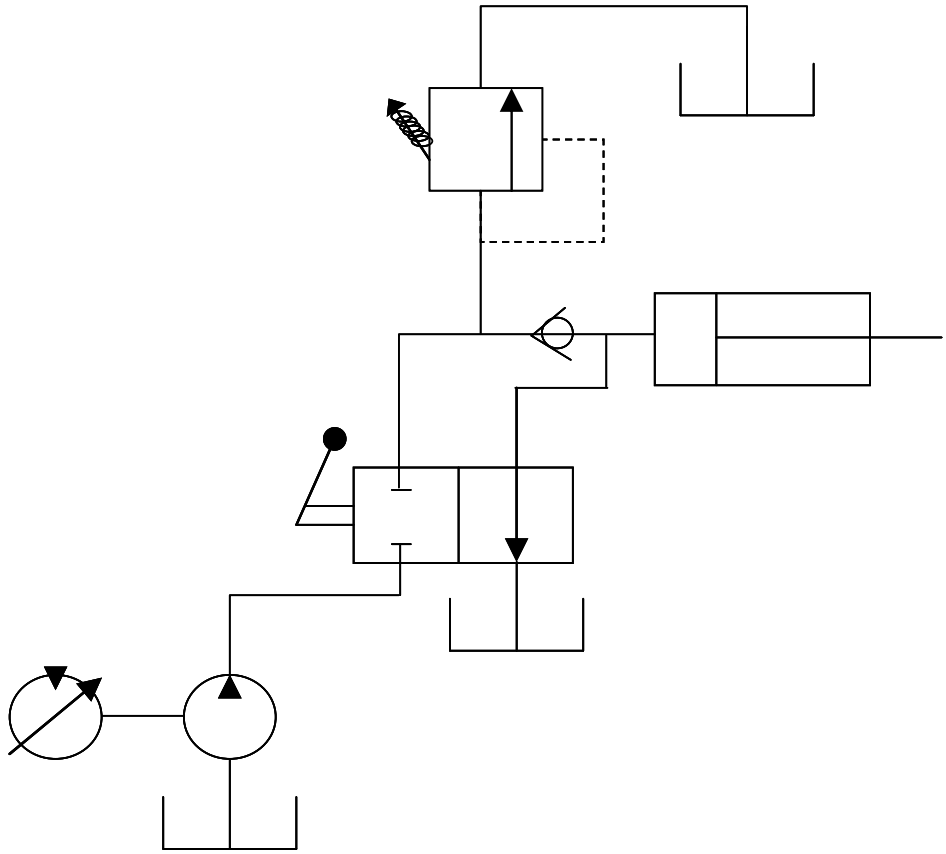
$$\text{Lift Time (sec)} = \frac{\text{Cylinder Piston Area (in}^2\text{) x Cylinder Length (in)}}{\text{Flow Rate (gpm)}} \times \frac{60 \text{ sec}}{1 \text{ min}} \times \frac{1 \text{ gal}}{231 \text{ in}^3}$$

For example, for the 3-pt hitch in the 8N Ford tractor:

$$\text{Time (sec)} = \frac{4.92 \text{ in}^2 \times 8.5 \text{ in}}{2.15 \text{ gpm}} \times \frac{60 \text{ sec}}{1 \text{ min}} \times \frac{1 \text{ gal}}{231 \text{ in}^3} = 5 \text{ sec}$$

This means that for the 8N tractor, it takes approximately 5 seconds to lift an implement (the same type of system in other tractors may have different lift times). The 5-second time interval is sufficient to be effective in work production, but is slow enough to minimize unexpected or uncontrolled movements by the tractor.

Figure 4. Schematic of the hydraulic components in the 3-Pt System



Power Point Presentation Tutorial on Ford N Series Hydraulics, by Rocky Carr –**View Online Here**

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REFERENCES

Ford Motor Company. 1950. Ford Tractor Operator's Manual, Model 8N. Item 3729-50-M. (Reproduction)