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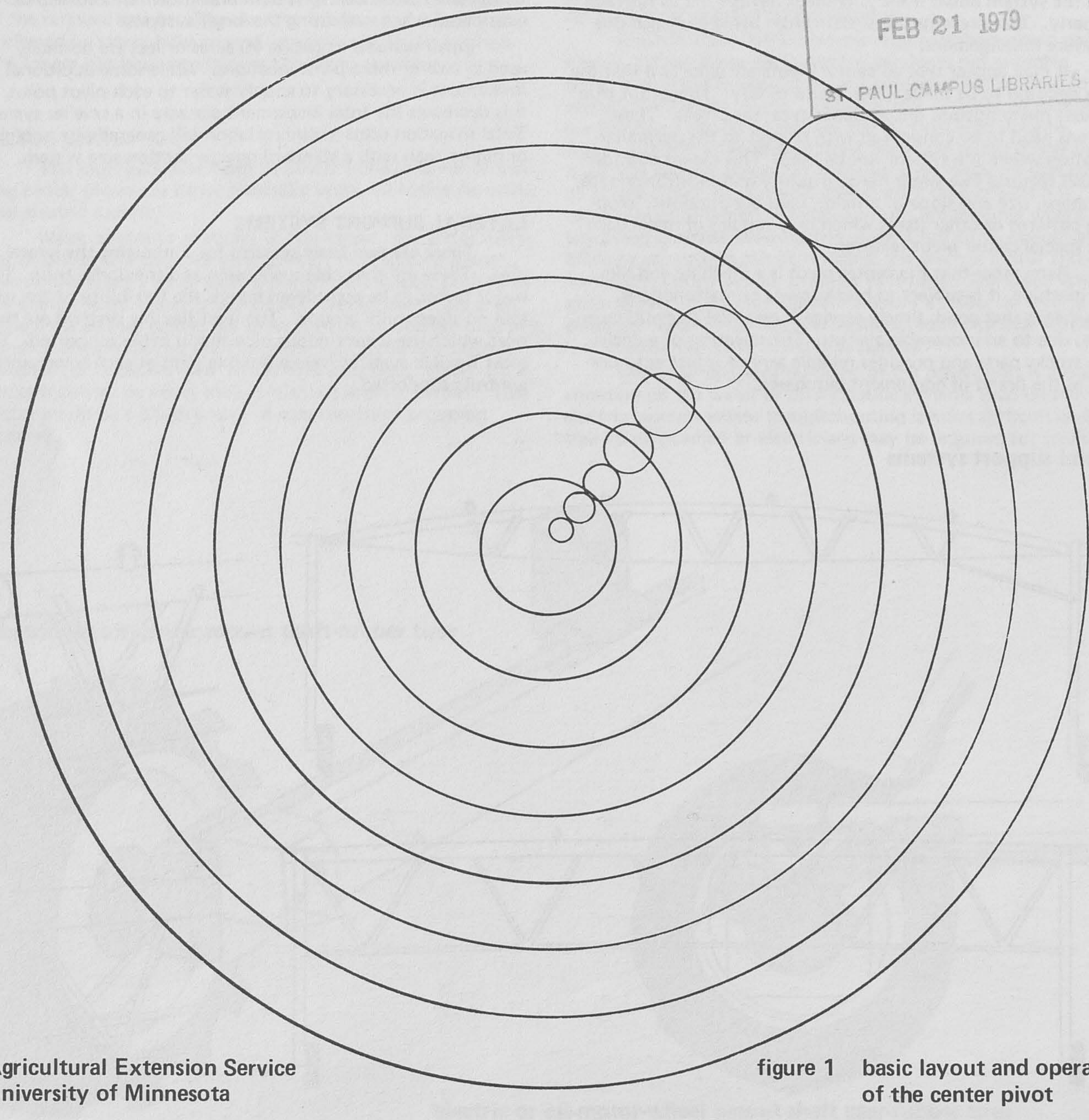
Selecting a Center Pivot



Agricultural Extension Service
University of Minnesota

figure 1 basic layout and operation of the center pivot

The center pivot is the most popular sprinkler irrigation distribution system in Minnesota. The basic layout and operation of the system is shown in figure 1. The system derives its name from its operation since it pivots about a point normally located at the center of the field.

The most common system is sized to operate within a quarter section of land. Water is supplied to the system at the pivot point and from there water moves through a lateral line supported by a series of towers. Sprinklers or spray nozzles spaced along the lateral deliver the water to the crop.

The lateral moves as the water is applied. Each tower is equipped with a power source, a drive mechanism, and an alignment device to keep the system in a straight line. The speed of rotation is determined by controlling the speed of the outer tower while the alignment devices control the movement of the other towers. Alignment control is accomplished by varying the speed of the towers or by starting and stopping tower movement as needed. Safety devices are located at each tower to shut the system down if the alignment devices fail to operate properly. This prevents the system from being damaged due to severe misalignment.

It may appear that all center pivots are alike and that the only decision to be made is the brand to buy. This is not true because many options are available in center pivots. These options need to be considered with respect to the particular situation where the system will be used. This means considering soil features like water holding ability and infiltration rate; the shape, size and slope of a field; field obstructions; cropping patterns or other items which may require or make desirable special center pivot features.

Remember that the center pivot is a machine and like any machine, it is subject to breakdowns or malfunctions. This means that good, timely service is essential to avoid crop losses due to an inoperable system. The selection of a dealer who stocks parts and provides reliable service is just as important as the brand of equipment purchased.

The following paragraphs discuss some of the options available on today's center pivots. Conditions which may cause certain features to be preferred are noted as well as conditions under which certain features may require special precautions.

SYSTEM SIZE

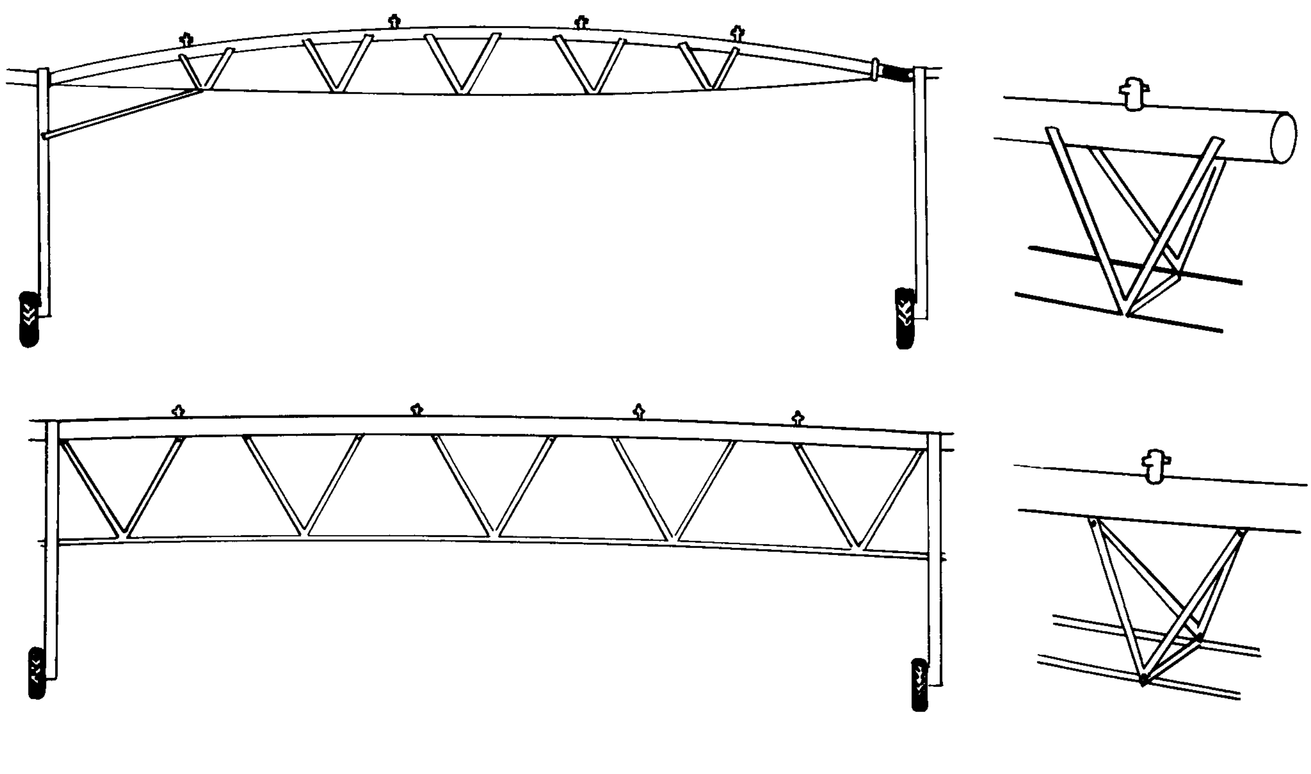
Center pivots are available from single-span, one tower systems which irrigate around six to ten acres per setting, up to full section-sized center pivots irrigating over 500 acres. For a single pivot location, systems about 1300 feet long near the quarter section size seem to be most practical. Smaller systems require a larger per acre investment when operated from a single pivot. Larger systems require proportionately greater amounts of water which result in increased application rates and a possible increase in operating pressures to overcome friction losses in the lateral. The relative amount of potential crop losses due to system breakdown should also be considered when evaluating the larger systems.

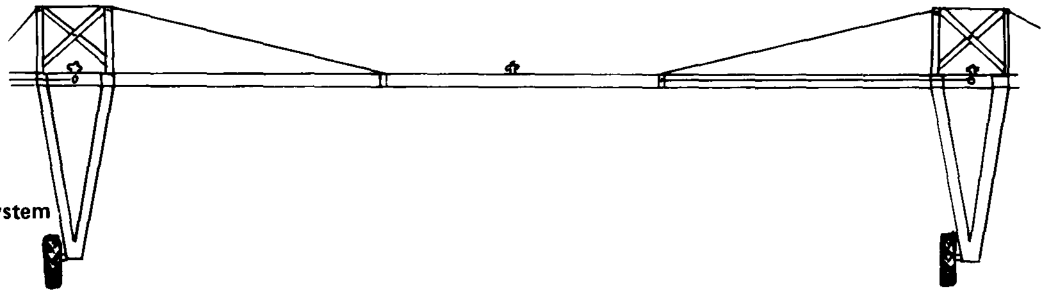
Small systems irrigating 40 acres or less are normally used at two or more pivot locations. While some additional investment is necessary to supply water to each pivot point, this decreases the total investment per acre in a smaller system. Total irrigation costs including labor will generally be as high or higher than with a standard quarter section-size system.

LATERAL SUPPORT SYSTEMS

There are two basic systems for supporting the lateral pipe. These are the cable suspension and the under truss. The major factor to be considered here is the flexibility of the system on steep, hilly ground. The least flexible systems are the ones which use a continuous pipe that is cable supported. The most flexible systems have a flexible joint at each tower and are truss supported.

lateral support systems





lateral support system

TOWER SPACING

Tower spacings or spans range from around 70 feet to 200 feet. The spacings affect the weight supported by each tower, the flexibility of the system, and the number of drive units needed. On fine-textured soils where flotation may be a problem, the short to medium spacings are desirable because of the reduced weight. The short to medium spacings are also preferred on steep, hilly ground where flexibility is required. The longer spacings are often less costly to purchase.

POWER UNITS

The most common types of power units used for propelling center pivots are water hydraulic units, oil hydraulic units, and electric motors.

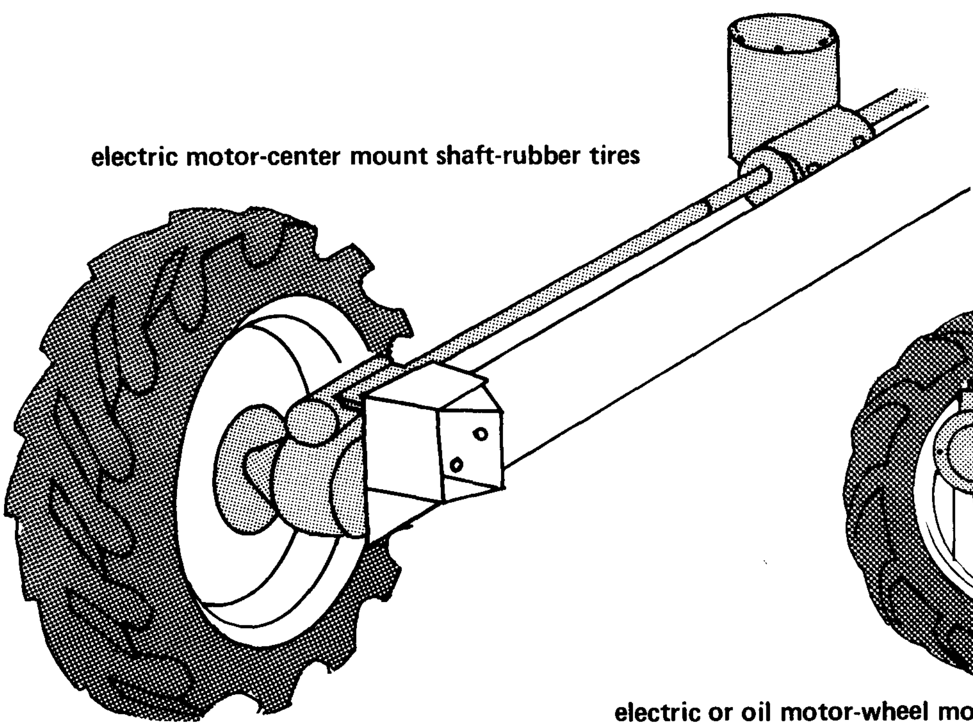
Water hydraulic units are of two types: the water cylinder or piston and the rotary or spinner. No separate power source is necessary with water drive systems since a portion of the energy in the water is being used. Design operating pressures must be maintained for these systems to operate properly. Sand or other impurities in the water may cause operational problems or excessive wear in the hydraulic unit. Water drive systems cannot be easily moved without applying water. This factor could be a disadvantage in some multiple cropping systems.

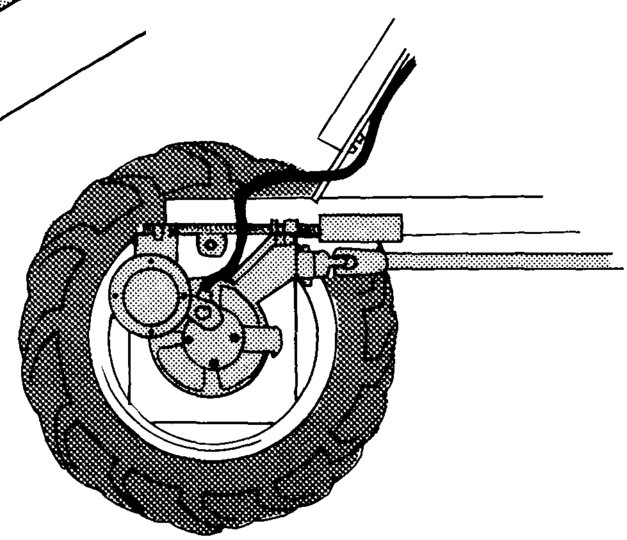
Oil hydraulic units are also of two types: the cylinder or piston and the rotary motor. The hydraulic pump requires either a separate power system or a special hookup to the water pump power unit such as a diesel engine. In the latter case, a clutch should be used so the water pump can be disengaged to operate the hydraulic pump separately so the system can be moved without applying water.

Electric motor drive systems require a three-phase power supply. Where three-phase electric service is not available either rotary-phase convertors or a generator can be used to supply three-phase power. The generator requires an external power source similar to that for the oil hydraulic systems. Again, a clutch is recommended if the water pump power unit is used to provide power for the generator. Systems that can be reversed may be desirable where more than one crop is being produced under a single pivot and are required where the farmstead or other obstructions prevent full circle operation. While most systems can be reversed, the electric motor and oil motor drive units are the simplest to reverse. The water spinner systems may require a moderate amount of labor to reverse while the water or oil cylinder systems require special adaptation and are the most difficult to reverse.

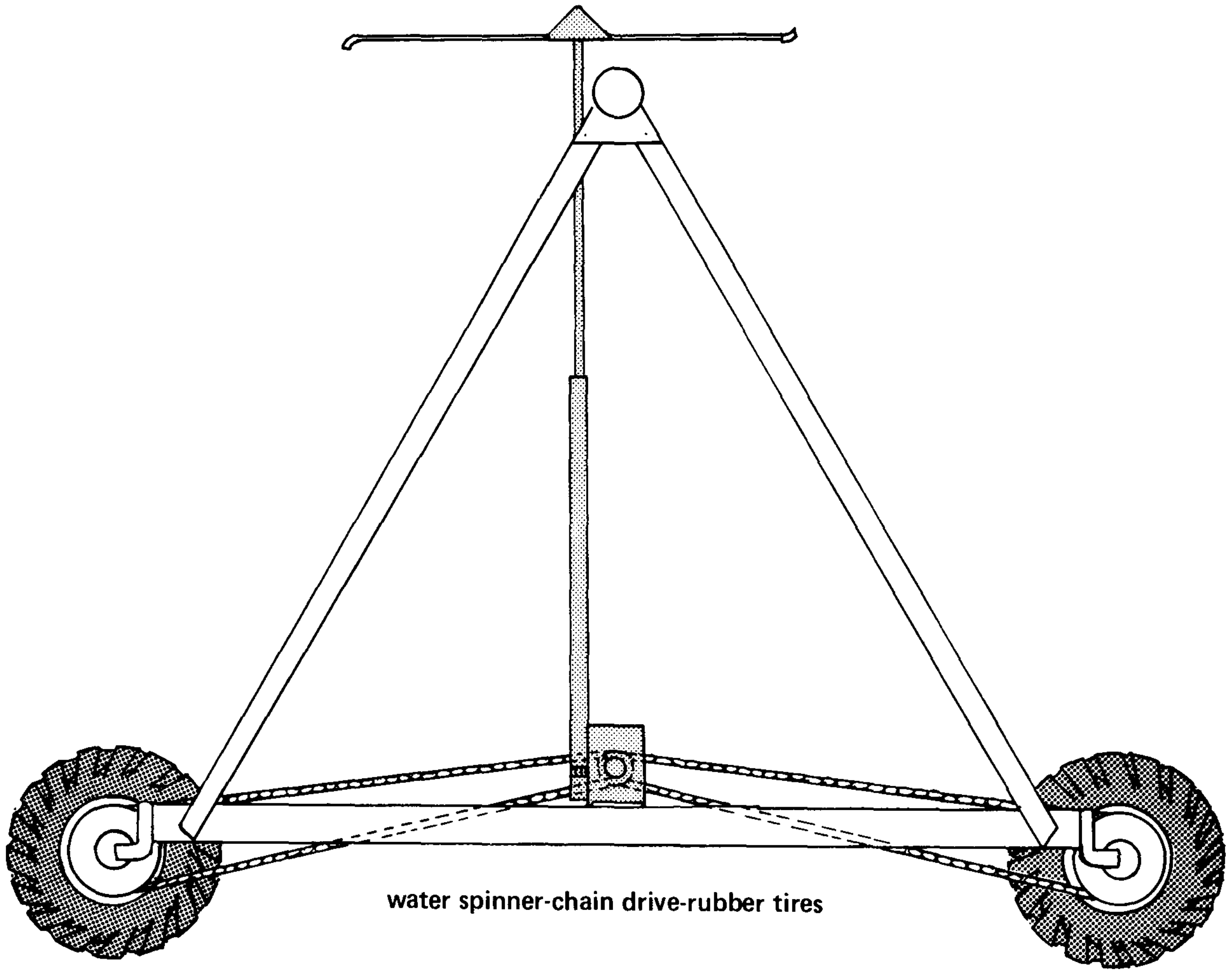
Owner or operator servicing of the power unit is more common on the water or oil hydraulic systems than on the electric systems where troubleshooting is more difficult and trained servicemen or electricians may be required for service.

electric motor-center mount shaft-rubber tires

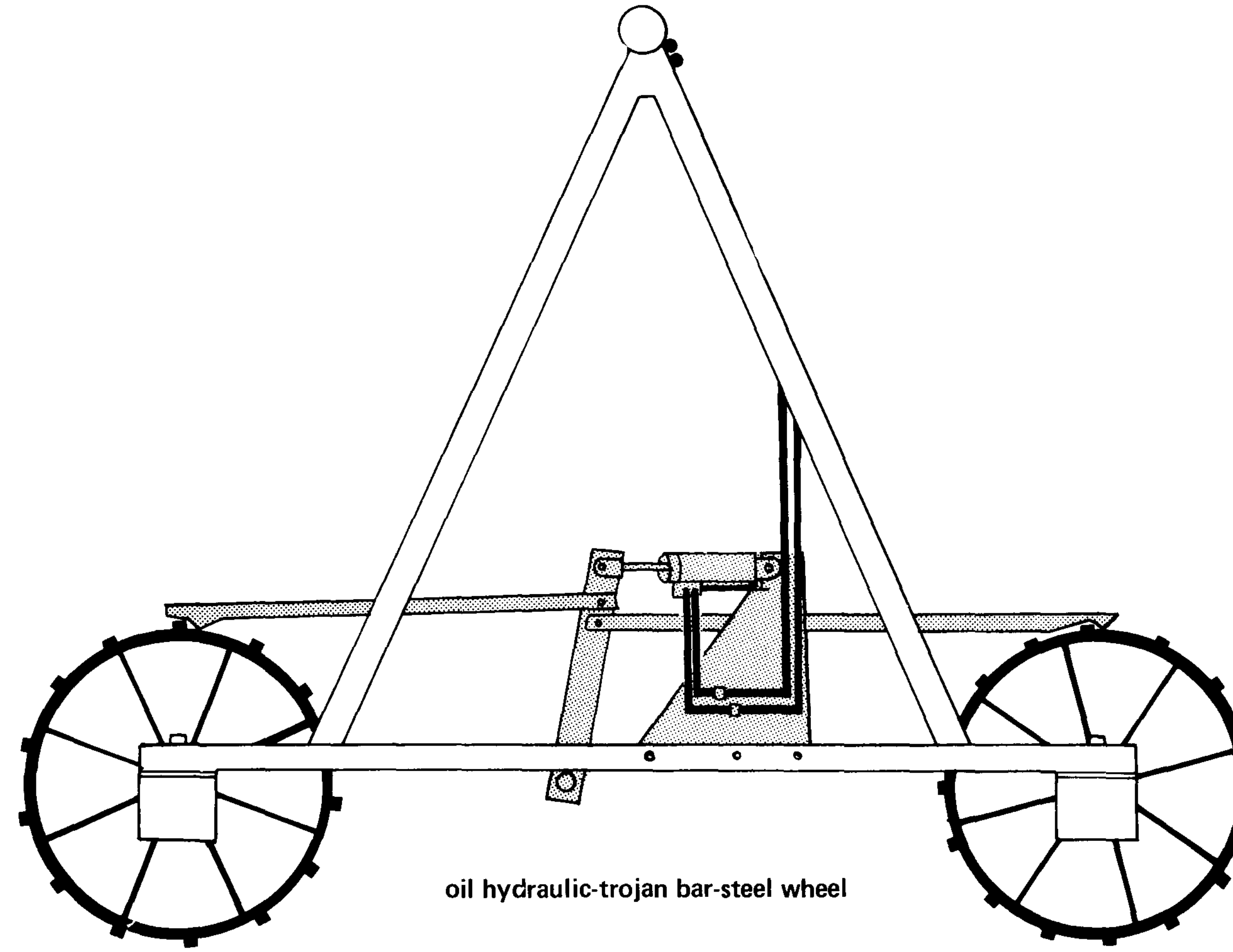




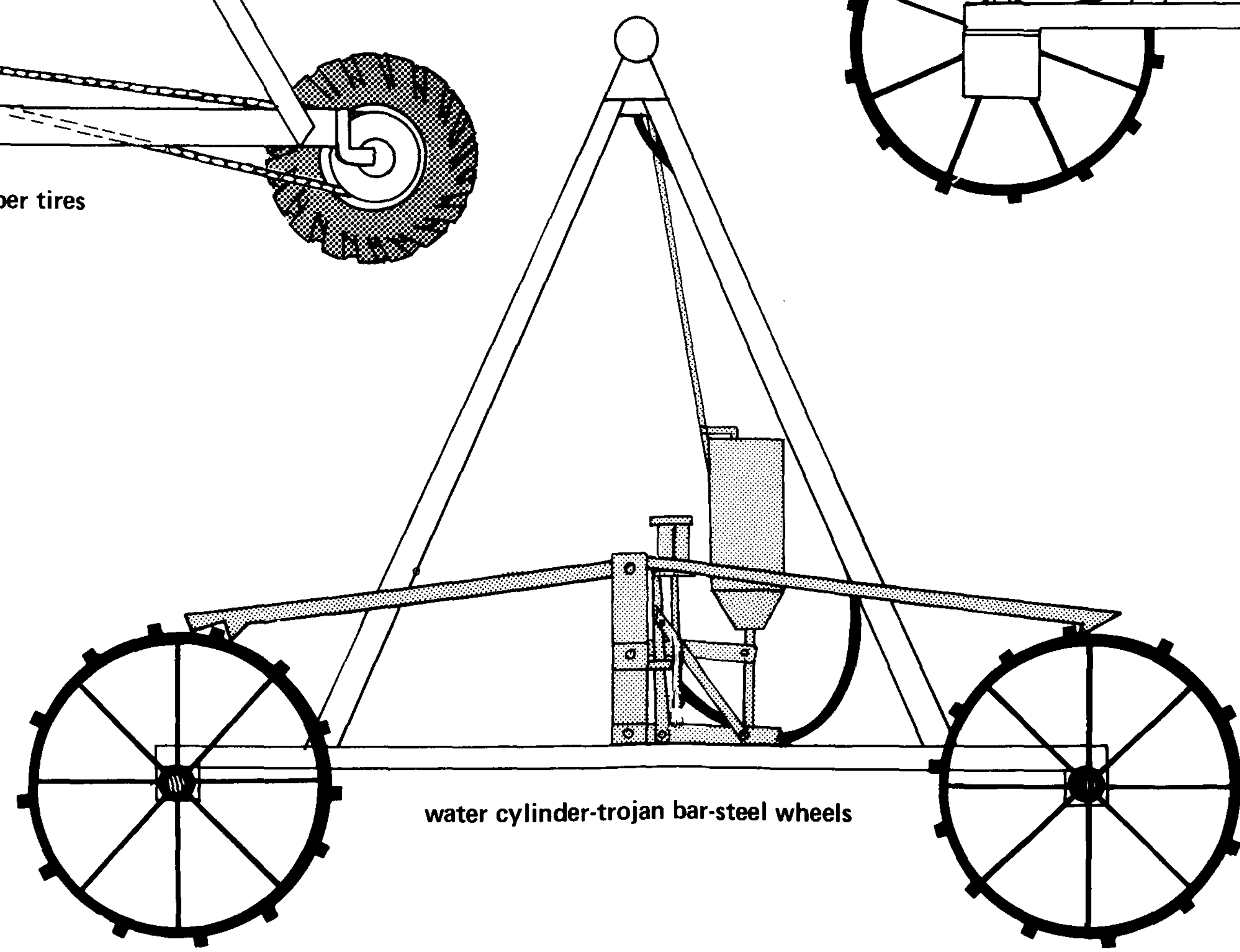
electric or oil motor-wheel mount shaft gear-rubber tires



water spinner-chain drive-rubber tires

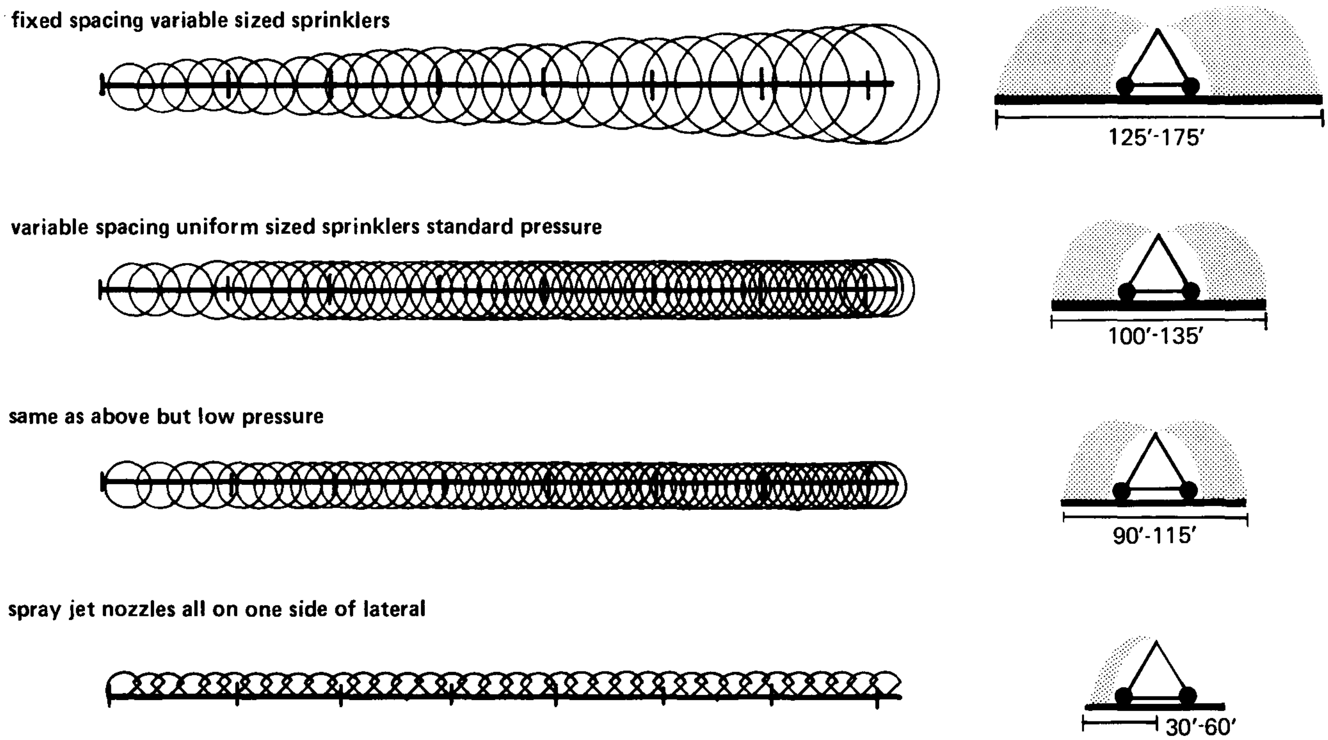


oil hydraulic-trojan bar-steel wheel



water cylinder-trojan bar-steel wheels

figure 2 three basic types of nozzling package options are being used



DRIVE TRAINS

Three general types of drive trains are used to transmit the power from its source to the wheels or where the power unit is located at one wheel to transmit the power to the other wheel. These types include trojan bars which are used on all water and oil cylinder systems plus chain and sprocket arrangements or gear trains. Systems with trojan bar drives may require brakes when used on steep or hilly ground. Without brakes the entire system may roll ahead or one tower may roll down a grade causing misalignment and system stoppage.

WHEELS

Either steel wheels or rubber tires are available. Systems using trojan bars require steel wheels. Soils with a high silt content appear to cause the most problem for traction and flotation. Rubber tires, possibly of a high flotation type, are preferred in this situation.

NOZZLE ARRANGEMENTS

Three basic types of nozzle packages are being used. These are shown in figure 2. Combinations or minor variations of these are used on some systems.

The arrangement identified as fixed spacing-variable sized sprinklers has been the most commonly used nozzle package. The smallest sprinkler is used near the pivot and towards the outer end each sprinkler must deliver an increasing quantity of water. This arrangement of sprinklers provides the lowest application rate, rate in inches per hour that water is being applied, but requires the highest operating pressure at the pivot, normally in the 75 to 85 psi range. Because of the lower application rate this package is normally recommended on soils with low infiltration rates or on sloping ground.

The arrangement identified as variable spacing-uniform sized sprinklers has a slightly higher application rate but a slightly lower operating pressure at the pivot, normally in the 60 to 70 psi range. An option with this nozzle package is the use of low-pressure impact sprinklers which operate in the 40 to 50 psi range. The application rate does, however, increase slightly at this lower pressure.

This package when operated at normal pressure tends to provide smaller droplets which may reduce surface damage to the soil if the system is operated without a complete crop canopy.

The arrangement identified as spray jet nozzles has a very high application rate. For this reason it is recommended for use on level fields with high infiltration rates. The major desirable characteristic of this arrangement is the low operating pressure which may be as low as 20 psi but is normally around 40 psi at the pivot.

The two primary factors in selecting a nozzle package are the application rate and the operating pressure. The application rate must be compatible with the soil or soils being irrigated and the operating pressure will affect both the investment cost and the operating costs of the pumping plant.

Some sample application rates are shown in table 1.

Table 1. Approximate range of peak application rates standard quarter section sized system 1280 feet long—no end gun

	System Capacity in GPM		
Nozzling Package	500	750	1,000
	(inches per hour)		
Fixed spacing-variable size	.55 - .75	.85 - 1.10	1.11 - 1.50
Variable spacing-fixed size			
Normal pressure	.70 - .90	1.05 - 1.30	1.45 - 1.75
Reduced pressure	.85 - 1.05	1.25 - 1.60	1.70 - 2.15
Spray jet nozzles			
Alternating	1.60 - 3.20	2.40 - 4.80	3.20 - 6.40
All on one side	3.20 - 6.40	4.80 - 9.60	6.40 - 12.80

These peak application rates are fixed by the type of sprinkler nozzling package used, the nozzle pressure, length of system and system capacity. They will not change with the speed of rotation. The total amount of water applied changes with the speed of rotation because this changes the time the system is over a given spot in the field while applying water at this fixed rate. Systems which have an application rate too high for the infiltration rate of the soils being irrigated may cause runoff from the field, within the field, and erosion.

SYSTEM DESIGN CAPACITY

The system design capacity is determined largely by the crop and soil being irrigated. In all cases, designing the capacity within a reasonable range is recommended. Excess capacity on high infiltration rate soils may not be damaging to the soil or crop but may require a larger pumping plant resulting in increased initial costs. On low infiltration rate soils, excess capacity increases the potential problem of water movement and erosion. Insufficient capacity is obviously never recommended. Normally the system size (acreage) should be adjusted to fit the water supply. However, in some situations, water management may still make irrigation economically feasible with what is considered to be insufficient water. This situation should be carefully investigated before proceeding.

For the commonly irrigated full-season crops in Minnesota the following table can serve as a guide for system capacities.

Table 2. Guide to system capacity based on predominant soil types

Predominant soil	GPM per irrigated acre	System capacity in GPM 130 acres irrigated
Gravels and coarse sands	7.0 to 9.0	900 to 1200
Fine sands, loamy sands and sandy loams	5.5 to 7.0	700 to 900
Loams, silt loams and clay loams	4.0 to 5.5	500 to 700

The coarser textured soils within each group should be nozzled nearer the upper end of the capacity range. The lower capacity figures shown for loams, silt loams, and clay loams, assume adequate soil moisture storage going into the irrigation season. Pre-irrigation or early season irrigation to increase soil moisture reserves may be necessary in some years. A thorough water management program is essential to the success of any irrigation project but increases in importance as the systems design capacity decreases. A publication on irrigation scheduling is available from County Extension offices to assist in establishing a water management program to fit different soil, crop, and system capacity conditions.

SPEED OF REVOLUTION

The speed of rotation of most center pivots can be varied over a wide range. Common rotation speeds are 60 to 96 hours per revolution and will typically apply about one inch of water. The net amount applied depends on the system design capacity, speed of rotation, and application efficiency which considers losses such as evaporation. A fast speed of revolution is important where field obstructions or cropping patterns require reversing or where some special requirement for applying small amounts of water may exist. One example of this is the application of herbicides through the system.

LATERAL PIPE

The lateral pipe carrying the water from the pivot to the outer end of the system comes in varying diameters and materials. The proper pipe diameter is dependent on system capacity and length. Too small a pipe will result in excessive friction loss between the pivot and outer end. An oversized pipe will normally be more expensive and will increase the weight of the system due primarily to the added water being carried.

Pipe materials and coatings should be selected primarily with respect to their expected length of life. User experience may be the best method available to evaluate these in regards to local conditions of water quality and climate.

OTHER

Several other features or options are available. These include:

End guns may operate continuously or only on selected portions of the field. Low pressure systems will need a booster pump to provide enough pressure to operate an end gun.

Corner systems are becoming increasingly popular. Since a corner system may add considerable acreage, one should be sure the water supply is adequate to handle the larger acreage. This is particularly important if a corner system is added to a previously operated center pivot. Certain pump characteristics are important to proper operation of a system that has a corner system. This fact should be discussed with a dealer if a corner system is added or a new system with a corner capability is bought.

Towing kits are optional on most systems. Towing from the pivot end is generally standard although some systems offer packages for towing from either end. If it is necessary or highly desirable to tow the system from the outer end, investigate this very carefully. If possible, visit an irrigator using this type of towing package and observe the system being moved.

Automatic controls are available including automatic reversing, shut-offs at pre-selected points, controls to prevent iceloads in near freezing temperatures, and remote operating or monitoring.

Each option should be evaluated from not only an economic standpoint but also the positive or negative effects it might have on the energy and water efficiency of the total irrigation program.

CONCLUSION

The center pivot is a very popular irrigation distribution system because of its low labor requirement and its relatively uniform water application pattern. Selecting the right system for the particular location and cropping program is not an easy task. Selecting the right dealer is just as important as the equipment selection. The dealer should provide: advice in the selection process, an efficient design, a quality installation, operating and maintenance instructions, and be prepared to do warranty work as well as provide continued back up parts and service.

Selecting the right equipment and dealer is only one step in developing a profit-making irrigation enterprise. **Before purchasing any equipment be sure of the water supply and obtain a water appropriation permit.** A high level of crop and water management is required in a successful irrigation operation. The County Extension Offices in the state can provide information on the recommended cultural practices for irrigated crop production.

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