

SPRINKLER #275
IRRIGATION

MASTER COPY

Supplement^{Conserv}
to the
Third Edition
1973

*Compiled and Edited
by*

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Textbook Re-editing Committee*

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Published by

Sprinkler Irrigation Association
13975 Connecticut Avenue, Suite 310
Silver Spring, Maryland 20906

CONTINUOUSLY MOVING MECHANICAL SPRINKLER SYSTEMS*

Most sprinkler systems apply water while the lateral and sprinkler are stationary. Mechanization of farm operations as labor costs increase, together with the shortage of labor for moving portable laterals and sprinklers, has resulted in improved and increased use of continuously moving mechanical sprinkler systems. These systems are characterized by laterals and sprinklers that remain connected to the main pipeline, but continuously move while applying water.

The three major types of continuously moving sprinkler systems are: 1. Circular center-pivot, 2. Straight moving lateral, and 3. Travelers. Chapter II, pages 20-23, gives additional information on these systems.

The stationary sprinkler systems apply water at a relatively constant hourly rate, while the moving system's application rates begin at zero, increase to a maximum, and then decrease to zero again as the moving system passes over a location. Figure II-1 shows a possible application rate curve for a continuously moving system.

The variable application rate of the continuously moving sprinkler system complicates the selection of an application rate for system design as compared with the design of stationary sprinkler systems. Possible intake rate curves for two soil types vs. water application curves for two positions under a moving sprinkler system are shown in Figure II-2. The typical application rate for the stationary system in Figure II-2. The typical application rate for the stationary system design is shown as the straight line at 0.22 inch/hour for the medium soil intake rate curve. No runoff is expected on the high intake rate soil, but the areas where the moving lateral application rate curves exceed the medium soil intake rate curve show the potential for runoff from a sprinkler system on this soil. A lower peak application rate would prevent runoff from the irrigated area, but this change would require that water be applied over a longer period of time to achieve the same depth per irrigation.

The quantity of water applied per irrigation also could affect the allowable moving sprinkler maximum application rate to a soil with-

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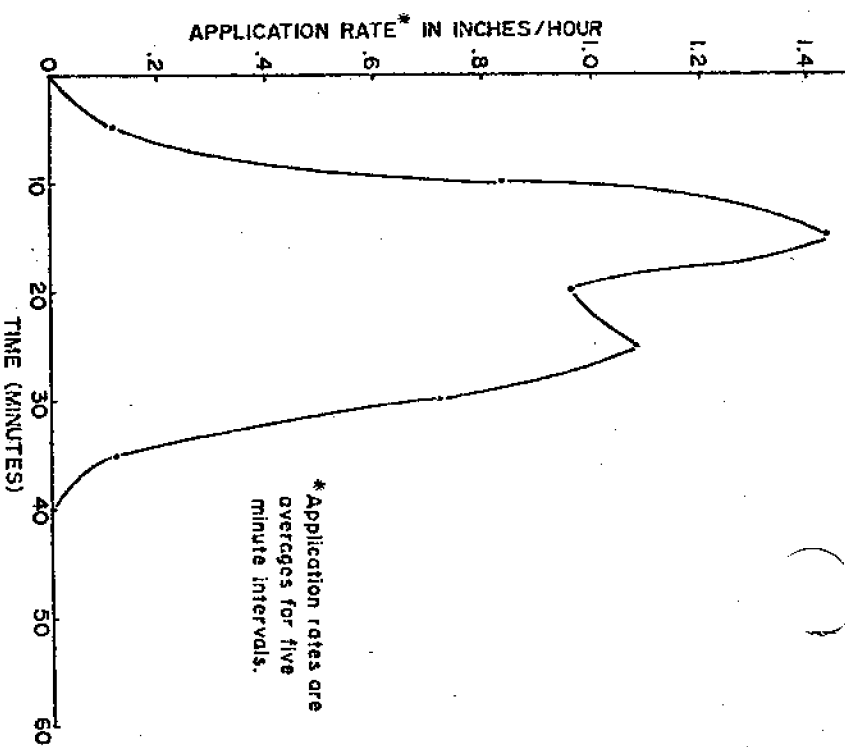


FIGURE II-1.

Typical application rate curve for continuously moving lateral. out runoff. Small depths of water applied frequently would allow the use of higher application rates than a larger depth applied in one application without runoff.

Equipment for determining the soil-water intake rate vs. time of water application curve of a soil is under development and uses simulated application rate patterns of a continuously moving sprinkler lateral. It has been suggested that the soil sprinkler water intake rate curve can be determined by setting catch cans at various locations across a stationary sprinkler lateral where the application rates vary. By measuring the time from the start of irrigation until water glistens on the soil surface just disappears as the revolving sprinkler returns to apply water again, and the depth of water caught in each can during this time for each can location, the application rate and time to runoff can be calculated. Plotting the water application rate in inches per hour vs. the time to runoff in hours will give the water intake rate-time of application curve for this soil.⁸

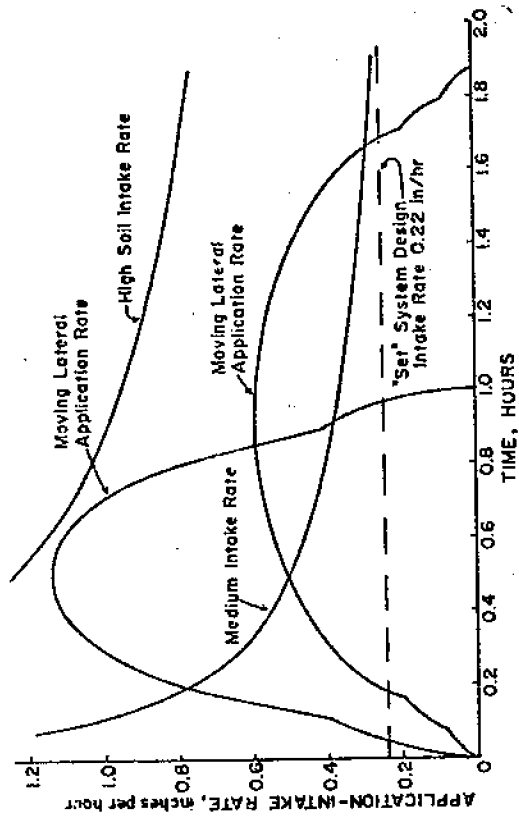


FIGURE II-2.

Soil intake and water application rate curves.

Rates from other moving systems on the same soil type of a mechanical analysis of the soil can be used as a guide in determining soil intake rates if the sprinkler field test cannot be made. On pages 62-65 in Chapter IV, soil intake rate principles are discussed.

CENTER PIVOT SYSTEMS

The Center-Pivot System was first patented in 1949. This type consists of a single sprinkler lateral with one end anchored to a fixed pivot structure and the other end moving in a circle about the pivot. Water is supplied to the lateral at the pivot point. The lateral is supported by towers and cables or trusses which move on wheel, track, or skid support units located 80 to 250 feet apart along its length. Lateral lengths vary from 200 to 2,600 feet.

The lateral is kept in a straight line as it moves around the pivot point by an alignment system that speeds up or reduces speed of support units or starts and stops movement of the support units as required to maintain alignment. Should the alignment system fail and support units get too far out of alignment, a safety device automatically shuts down the entire sprinkler system before the lateral can be damaged. A mechanism for propelling the lateral is mounted on each lateral support structure.

The five types of power units for propelling a center-pivot sprinkler system are:

1. Hydraulic water drive
 - a. Piston
 - b. Rotary
2. Hydraulic oil drive
 - a. Piston
 - b. Rotary
3. Electric motor drive
 - a. Piston
 - b. Rotary
4. Air-pressure drive
5. Mechanical or cable drive

The piston on each support carriage of the hydraulic piston water-driven system is powered by water from the sprinkler lateral pipe. The operating piston activates a set of trojan bars which in turn engage wheel lugs to turn the support wheels (Figure II-3).

A rotating, reaction-type motor assembly mounted on a shaft of the rotary water drive systems drives the wheels of each support carriage through a gear train or by a chain and sprocket mechanism as shown in Figure II-4. Operating pressures at the pivot for drive systems range from 60 to over 120 psi. In each case the water consumed by the drive unit is discharged to the crop, either directly by the spinner or by other means.

An electric motor or internal combustion engine-driven oil pump and oil reservoir at the pivot (Figure II-5) maintains 600 to 2,000 psi oil pressure in the oil supply line to drive the hydraulic oil systems. The oil supply and return flow pipelines extend from the oil pressure pump to the piston drive units or to a rotary motor located on each support carriage in most systems. If a piston is used, it actuates a set of trojan bars which engages wheel lugs to turn the wheels. If a rotary motor is used, the power is transferred to the wheels through a chain and sprocket drive combination.

The electric motor drive systems have motors of 1/2, 3/4, 1, or 1-1/2 hp. mounted on each support carriage. Most systems operate with 440- to 480-volt, 3-phase, 60-cycle electric power. The control circuits are usually 110 volts. Electrical power is supplied by an engine-driven generator, located at the center pivot, or by an underground cable which conveys the electric power from a commercial source to the center pivot. A slip ring connector at the pivot point connects the power source to the moving lateral wiring. The drive motors turn the carriage support wheels by the use of a chain and sprocket mechanism or through a gear drive as shown in Figure II-6.

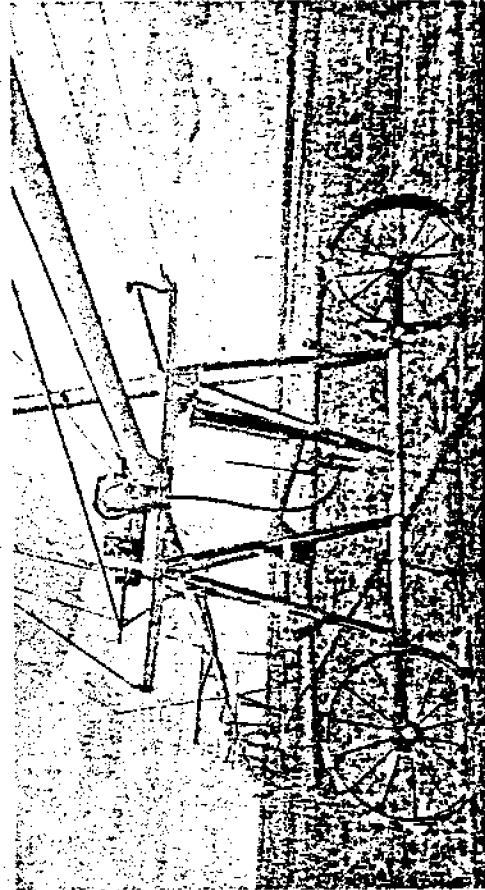


FIGURE II-3.

A hydraulic drive mechanism, piston type.

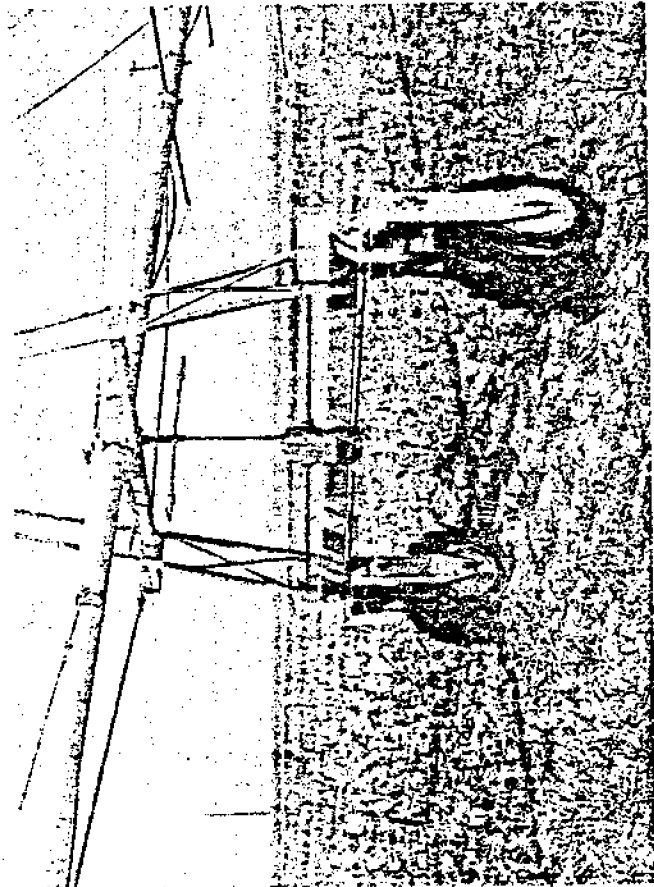


FIGURE II-4.
Hydraulic rotary drive mechanism.

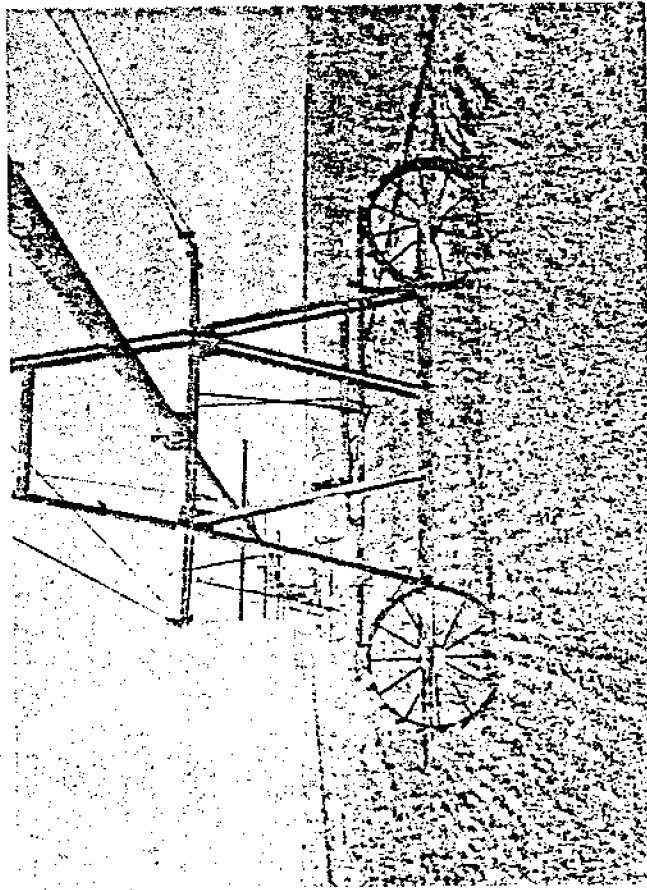


FIGURE II-5.
Oil drive mechanism.

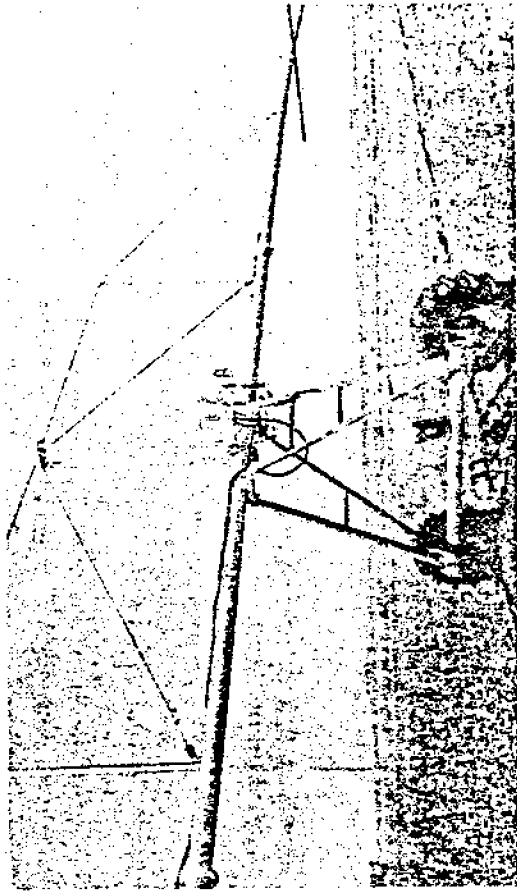


FIGURE II-6.
Electric drive mechanism.

The air drive systems have a heavy duty compressor driven by either the pumping plant power unit or an auxiliary power unit which supplies compressed air to a cylinder and torsion bar drive mechanism that turns the carriage support wheels. A safety valve releases air pressure and stops the system if a carriage gets stuck or too far out of alignment.

Early center-pivot sprinkler systems had laterals with rigid pipe couplings. These were satisfactory for use on level or uniformly sloping lands, but on rolling land, pipe breakage could result. Now, manufacturers supply laterals with flexible pipe couplings (Figure II-7) which can be used on rolling land.

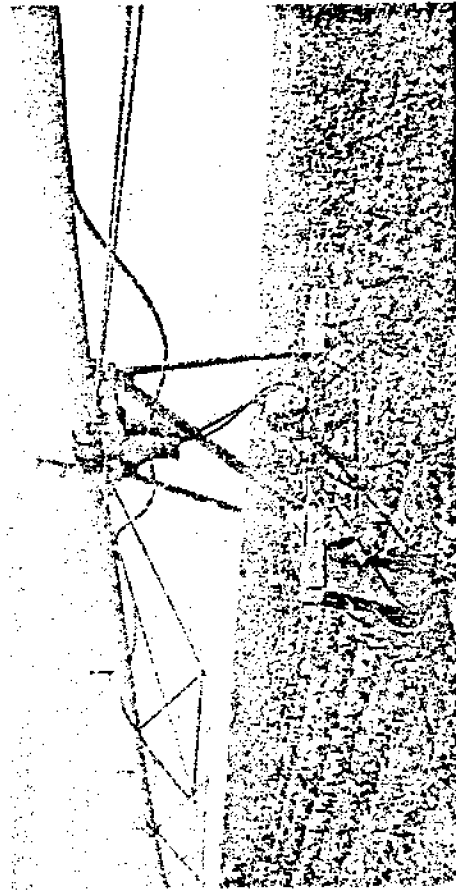


FIGURE II-7.
Flexible pipe coupling.

Water Application Rates along a center-pivot lateral are determined by the nozzle sizes, nozzle pressure, sprinkler spacing, length of lateral, and lateral types used. Once the above parameters are set, the rate of water application remains fixed, regardless of the rotation speed of a center-pivot lateral. Changes in lateral rotation speed will change only the duration of application and the depth of water applied.

The water application rate varies along the lateral length from a low value near the pivot to higher values at the outer end. Figure II-8 illustrates why the application rate must increase toward the outer end of a lateral. Beginning at the center-pivot, water is applied along 660 feet (one-half) of lateral to irrigate the inside one-fourth of the total area, while the outside one-fourth of the area requires that the same volume of water be applied through 177 feet of lateral.

WATER APPLICATION ALONG LATERAL

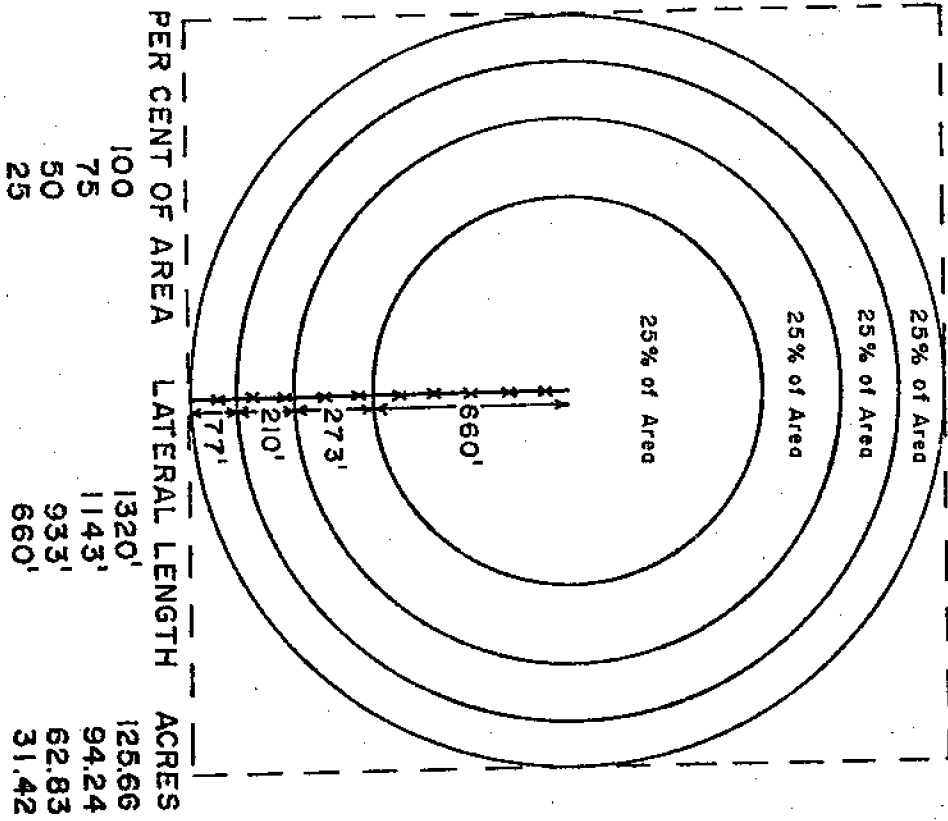


Figure II-8. Area - lateral distances for uniform water distribution.

Water application rate varies along a center-pivot lateral also because the lateral travel speed increases from the pivot to the outer end. Table II-1 illustrates the time water applied at four positions from the center pivot using different lateral speeds to make a complete lateral revolution and two types of sprinkler arrangements along the lateral.

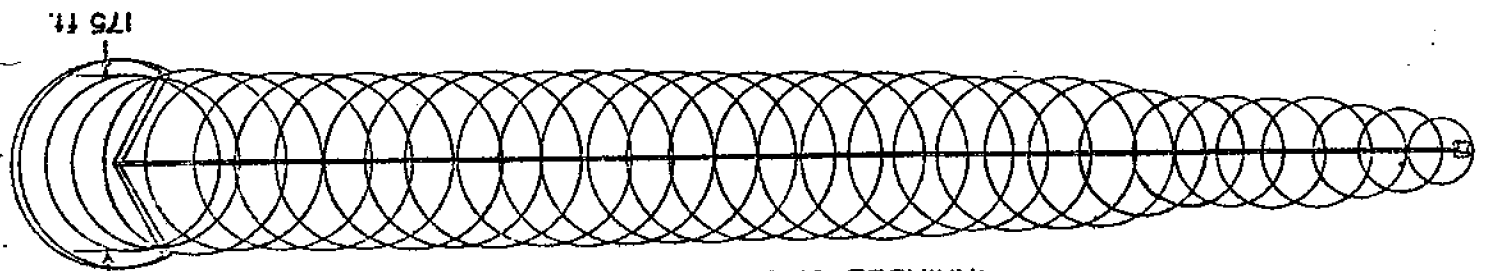
TABLE II-1
Time of Water Application for Various Points along a Center-Pivot Lateral for Two Sprinkler Arrangements

| Time of one lateral revolution hrs | Sprinkler spaced | | Sprinkler position along lateral from pivot, in feet | | | | | |
|---------------------------------------|------------------|-------|--|-------|-----|--------|-----|--------|
| | 90° | 80°** | 90° | 90°** | 90° | 130°** | 90° | 175°** |
| 6 | 31 | 28 | 16 | 16 | 8 | 12 | 4 | 8 |
| 12 | 63 | 56 | 31 | 31 | 16 | 22 | 8 | 16 |
| 18 | 94 | 83 | 47 | 47 | 23 | 34 | 12 | 23 |
| 24 | 125 | 111 | 63 | 63 | 31 | 45 | 16 | 30 |
| 36 | 185 | 167 | 94 | 94 | 47 | 68 | 23 | 46 |
| 48 | 250 | 222 | 125 | 125 | 63 | 91 | 31 | 61 |
| 60 | 313 | 278 | 156 | 156 | 78 | 113 | 39 | 76 |

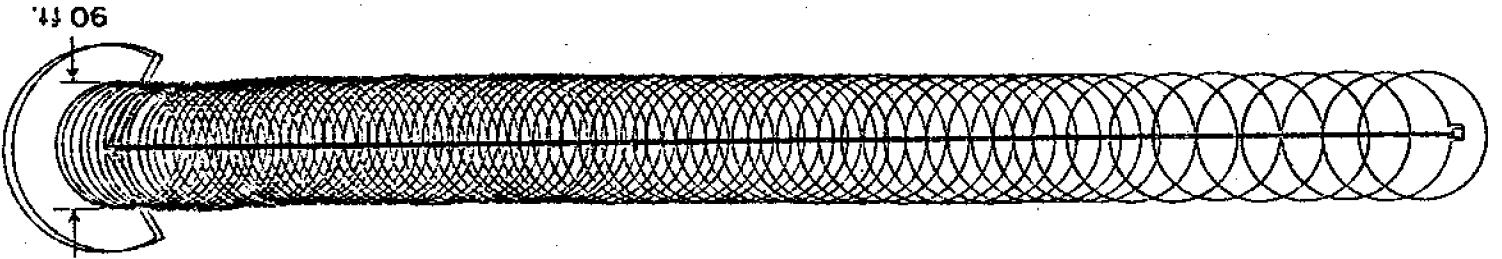
*All medium-type agricultural sprinklers.
**Sprinklers vary from small type at pivot to large type near outer end of lateral.

The type of sprinklers, their spacing along the lateral, and the diameter of sprinkler coverage affect the application rates of a center-pivot lateral. There are three common variations in sprinkler type and arrangements used on center-pivot laterals with the sprinklers in fixed or variable spacings. In one arrangement, some of the smallest agricultural sprinklers are used near the pivot point, medium-sized sprinklers near the middle of the lateral, and large-type sprinklers at the outer end of the lateral. In the second arrangement, all medium-sized agricultural sprinklers are used with a variation in nozzle sizes along the lateral with the smallest nozzles at the pivot and the largest nozzles at the outer end of the lateral. In the third arrangement, spray-type nozzles are used which are small near the pivot and large at the outer end of the center-pivot system (Figure II-9). All systems have a high degree of uniformity if designed properly.

The spray-type nozzle sprinkler gives the highest application rates along the lateral because of the narrow width of coverage. An advance is lower operating pressures, which are usually about 40 psi. A measured average application rate at a point 1,300 feet from the pivot of one system gave 3.35 inches per hour, and water was applied to one area for 5-1/2 minutes during a 22-hour lateral revolution.



ALL MEDIUM SIZE SPRINKLERS



SPRAY JET SPRINKLERS



CENTER PIVOT WATER APPLICATION PATTERNS ALONG LATERAL

Medium-sized sprinklers with various size nozzles along the lateral have the next highest application rates because the width of coverage is about 90 feet along the lateral. These sprinkler systems usually have lower operating pressures than do systems with large sprinklers. The manufacturer recommends 50- to 60-psi pressure for best operation of medium-sized sprinklers. A 65- to 75-psi operating pressure is usually required at the pivot point.

Lowest water application rates can be obtained with laterals employing small to large sprinklers. On a 1,300-foot center-pivot lateral, the end sprinklers wetted an area of approximately 175-foot diameter. The manufacturers of the larger sprinklers recommend from 70- to 90- psi pressure for best sprinkler operation and drop size distribution. Operating pressures at the pivot point range from 75 to 110 psi to give the best water distribution and droplet size. Table II-2 shows the average water application rates along a 1,265-foot center-pivot lateral having different size sprinklers and 1,000 gpm lateral discharge.

TABLE II-2

Average Water Application Rate Measured along a Center-Pivot Lateral

| Distance from pivot | Average application rate |
|---------------------|--------------------------|
| ft | in/hr |
| 95 | 0.21 |
| 185 | 0.22 |
| 275 | 0.25 |
| 365 | 0.35 |
| 455 | 0.35 |
| 545 | 0.39 |
| 635 | 0.43 |
| 725 | 0.45 |
| 815 | 0.45 |
| 905 | 0.53 |
| 995 | 0.65 |
| 1085 | 0.72 |
| 1175 | 0.81 |
| 1265 | 0.83 |

The measured peak application rate between the two outside towers for two center-pivot systems, one having all medium-sized sprinklers and the other having variable size sprinklers, gave 2.5 and 1.4 inches per hour, respectively, for a 5-minute time period. The laterals were both the same length and applied 900 gpm.

The Design of a Circular Center-Pivot System follows the general steps given in Chapter III for obtaining the basic data needed. Design capacity of a center-pivot lateral is calculated from the peak water use rate of the main crop, the area irrigated, and the water application efficiency when the system is operated continuously during the period of peak water use rate.

Crops and climate determine the peak water use rate for an area. Methods of determining crop requirements and peak rate of use are described in Chapter IV.

The area irrigated is determined by the length of the center-pivot lateral and the percent of a full circle operation. The following equation can be used to calculate areas:

$$A = \frac{\pi R^2 p}{43,560 \times 100} \quad [1]$$

where A is the area in acres, R is the length of the lateral in feet, and p is the percent of a full circle irrigated.

The quantity of water to be delivered to the center pivot of a system is calculated by the following equation:

$$Q = \frac{1890 E_p A}{E_l} \quad [2]$$

where Q is in gallons per minute, E_p is the peak water use rate of the crop in inches per day, E_l is the water application efficiency in percent, and A is the area irrigated in acres.

The water application efficiency, defined in Chapter V, page 126, varies with the water distribution uniformity of the lateral and whether the water applied goes into the soil at the point of application. Anderson and Brown report water application efficiencies of a center-pivot system in the Columbia Basin area of Washington that varied from 70 to 80 percent during one irrigation season.

Several charts have been prepared for the solution of Equation [2], with either the efficiency held at one value (Figure II-10), or the acreage irrigated held at a fixed value (Figure II-11).

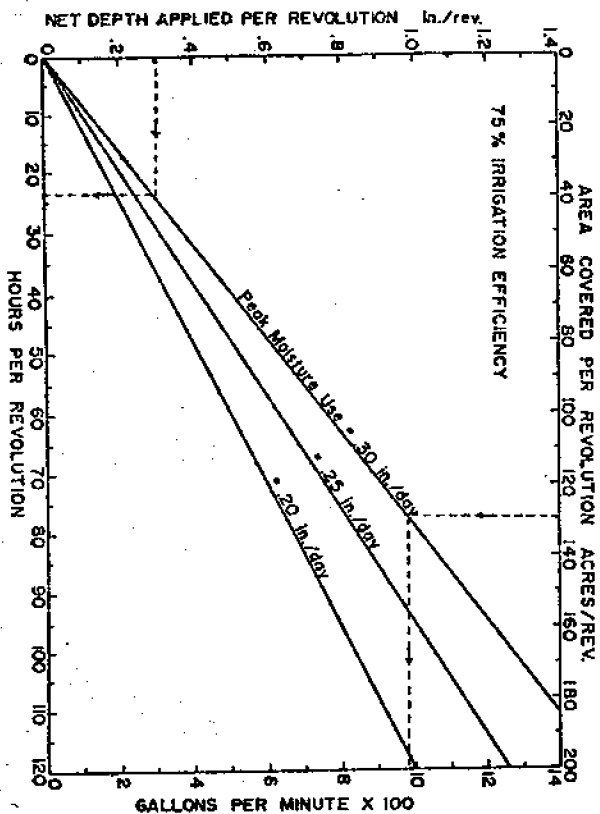


FIGURE II-10. Center-pivot system capacity chart for one irrigation efficiency.

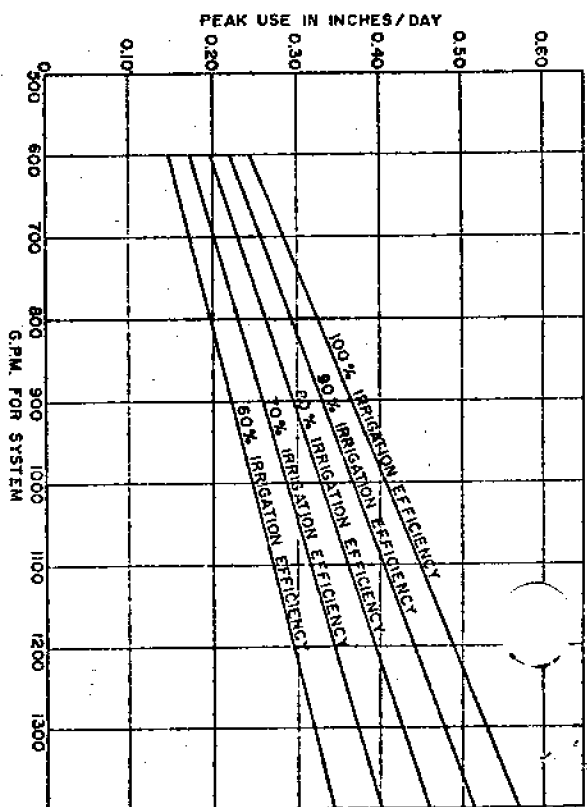


FIGURE II-11. Center-pivot system capacity chart for 130 acres.

An alternative method of designing center-pivot systems is being used in some areas where frequent rainfall and soil moisture storage in the crop root zone can be utilized to supply part of the water to the crop during the peak use period. This permits a reduction in the design peak use rate for the system. This reduced design peak use rate is then used in equations [2] and [3] which will reduce the volume of water (Q) required for the system design and the average maximum application rate at the outer end of the center-pivot lateral. A factual knowledge of the rainfall frequency and amounts, the soil-moisture-holding capacity in the crop root zone, and the actual peak water use of the crops is necessary before designing a successful system under this method.

David W. Fonkin lists the following instructions when using this alternate method of design:

1. The practice of starting the season with a full profile is essential.
 2. The root zone must have sufficient soil moisture holding capacity to supply, without stress, the balance of the crop water requirements not supplied by irrigation or rainfall.
 3. The irrigation system must operate without down time during the peak use period, or some safety factor must be provided.
 4. Consideration should be given to the possibility of a different efficiency and an appropriate adjustment made.
 5. Lower and lower levels of system capacity call for higher and higher levels of irrigation management and system reliability.
- ASAE Recommendation R264.4, Item 3.2.1, Minimum Requirements for the Design, Installation, and Performance of Sprinkler

Equipment specifications. For regularly irrigated areas, the system shall have the capacity to meet the peak moisture demand of each and all crops irrigated. When the area for which it is designed. However, if the purchaser deems that an amount of water less than necessary to meet peak demand is desirable, then the design capacity will be that stated by the purchaser in writing.

Assuming that the water application rate pattern of a center-pivot lateral is elliptical, Dillon, Hiler, and Vittetoe¹ have developed the following formula to estimate the maximum application rate:

$$h = \frac{122.5 Q}{R r} \quad [3]$$

where h is the maximum application rate of the last few sprinklers in inches per hour, R is the wetted radius of the center-pivot sprinkler lateral in feet, r is the wetted radius of the last few sprinklers on the lateral in feet, and Q is the center-pivot system capacity in gpm.

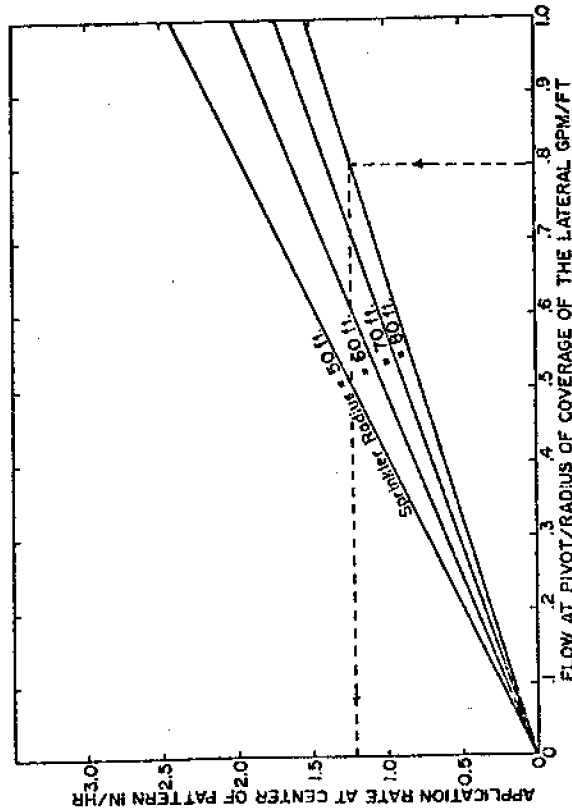


FIGURE II-12.

Graphical solution for application rate at center of elliptical pattern.¹

Figure II-12 is the graphical solution of the above equation. If the calculated maximum water application rate of the lateral is less than the intake rate for the soil, runoff will not occur on all but rolling lands. If the peak application rate is higher than the soil intake rate, a shorter lateral can be used although it would irrigate a smaller area, or the water discharge capacity of the total system reduced but not below crop needs.

In some sloping areas where the application rate may exceed the soil intake rate, contour or cross-slope farming, basins between crop rows, or tillage practices may be used to retain the water at point of application and prevent runoff. Water runoff is more of a problem on sloping or rolling lands. Level lands usually do not have the runoff problem.

The average gross depth of water applied by a center-pivot system during each revolution depends upon the area irrigated, capacity, and time needed to complete one lateral revolution and can be calculated by the following equation:

$$d = \frac{QH}{A \times 453} \quad [4]$$

where d is gross water applied in inches, Q is the flow at the center pivot in gpm. H is the time of one lateral revolution in hours, and A is the area irrigated in acres.

Operation of the System. The success of any center-pivot sprinkler is dependent on the proper design, installation, and operation of the system. The design and installation should be the responsibility of the manufacturer, distributor, and dealer. The correction operation is the responsibility of the farmer or his employee. See Chapter XI for additional operation and maintenance suggestions.

Manufacturers provide an operator's maintenance manual that gives detailed steps necessary to prepare the center-pivot system for operation at the beginning of each irrigation season, maintenance necessary during operation, and the steps that should be taken to prepare the system for long periods when it is not in use. This manual should be obtained and used by every operator.

Each year, before the irrigation season, the sprinkler system should be thoroughly inspected for needed repairs, maintenance, and proper operation of all system parts. All moving parts that require lubrication should be greased with the correct type, grade, and amount of lubricant. Usually, the operator's maintenance manual will give the lubrication specifications. Sprinkler heads and nozzles should be examined and repaired or replaced so midseason repairs will not be required. Leaks in the lateral pipeline should be repaired. On electrically powered machines, the use of a pressurized spray contact cleaner to clean contact points on electrical controls may prevent system shutdown later in the season. **CAUTION:** Make sure all electrical power is disconnected from the system before cleaning any electrical contact points.

System management includes the timing of water applications to meet crop requirements and necessary soil water storage. The center-pivot system is designed to apply water at a peak use rate when operating continuously. At times during the season, crop water consumption is less than in the peak use period of the season. During these times, intermittent operation of the system should be practiced.

Enough water should be applied to bring the root zone to field capacity. When the lateral returns to the starting point, check the soil moisture to see if enough water has been used to warrant starting the lateral around again.

Crop water needs should be anticipated. The soil profile should be near field capacity before peak use begins to avoid excess plant stress in the event of a breakdown for a day or more, especially on low waterholding capacity soils. The lateral must be repaired in the field and usually another lateral is not available for substitution for the disabled one.

When freezing temperatures occur, the irrigator must be careful in operating the system. At these times, ice accumulating on the sprinkler lateral pipeline and supporting structure can overload and collapse the system. Low temperature kill switches are available from most manufacturers.

Moving systems operate best on soils which absorb the water at the point of impact. When water is applied by any method faster than the soil can absorb it, runoff occurs, resulting in poor crop irrigation and excessive soil erosion. Runoff may collect in low areas causing a loss in load-bearing strength of the soil and possible bogging down of the wheels, tracks, or skids.

CONTINUOUSLY MOVING STRAIGHT LATERAL SYSTEMS

The continuously moving straight lateral irrigates a rectangular field. The lateral pipeline with sprinklers is supported on two-wheeled carriages at 40- to 80-foot intervals along the lateral. Water from the main pipeline is supplied to the lateral through a high pressure flexible hose. A power unit drives a winch that winds up a steel cable towing the power unit, 660-foot length of hose, and the end support carriage across the field. The remaining support carriages are driven individually by an arm-type spinner sprinkler through a gear box or shaft chain-drive mechanism. A lateral alignment system decreases the pressure and volume of water on the drive sprinkler if a support carriage gets ahead of the line of carriages, or increases the pressure and volume of water to the drive sprinkler if a support carriage gets behind the lateral alignment. Clearance of crops by the lateral pipeline of present models is 7 feet. Rate of lateral travel can be varied from 0.5 to 2.0 feet per minute.

The Design of a Continuously Moving Straight Lateral System follows the general steps given in Chapter III for gathering the basic data for use in calculating system capacity.

Methods of determining crop requirements and peak rate of water use for an area are described in Chapter IV.

Chapter V, page 126, defines the water application efficiency. It varies normally from 75 to 80 percent, depending upon the uniformity of water distribution and on the assumption that water is retained in the root zone of the crop at the point of application.

The quantity of water that should be delivered to the straight moving lateral is calculated by using equation [2].

Water application rates to the soils along a continuously moving straight lateral are determined by the nozzle size, water pressure, and spacing of sprinklers. The peak application rate should be approximately the same at all points along this type of lateral. Lateral travel speed does not affect the water application rate. The depth of water applied is a function of application rate and lateral travel speed. Figure II-13 shows the water application rate pattern for two speeds of travel of the same lateral.

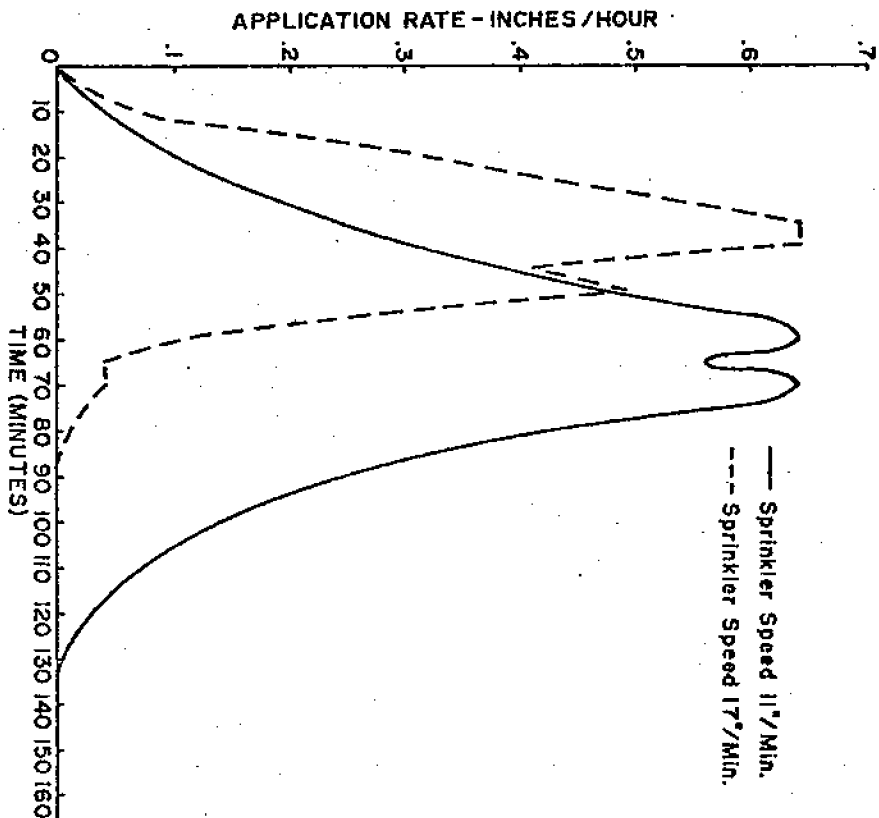


FIGURE II-13.

Water application rate pattern - two lateral speeds.

If the water application rate pattern of a continuously moving lateral is assumed to be elliptical in shape, the following equation can be used to calculate the maximum application rate of the lateral:

$$h = \frac{61.3}{r} \times \frac{Q}{L} \quad [5]$$

where h is the maximum application rate in inches per hour, Q/L is the water applied per foot length of lateral in gpm, and r is the wetted radius of the sprinkler in feet.

The application rate of a continuously moving straight lateral can be changed if the application rate is too high or too low for the soil water intake rate by changing sprinkler nozzle sizes and pressures. If the application rate needs to be decreased to prevent runoff, the speed of lateral movement will need to be reduced to apply the same total depth of water. This will mean a decrease in acreage that can be irrigated by a system in a given period.

The average gross depth of water applied by a continuously moving straight lateral at each irrigation depends upon the area irrigated, the rate of water flow at the lateral inlet, and the time needed to complete one irrigation.

$$d = \frac{QH}{453 A} \quad [6]$$

where d is average gross water depth applied in inches, Q is the flow at the lateral inlet in gpm., H is the time needed to irrigate the area in hours, and A is the area irrigated in acres.

Operation of a Continuously Moving Straight Lateral will depend upon the brand of system, and the dealer-installer should instruct the owner in the proper procedures. One straight moving lateral has wheels on the supporting carriages that can be turned 90°. This lateral irrigates down one side of the main pipeline, after which the irrigator turns the wheels, and then the lateral returns, irrigating to the straightens the wheels, and then the lateral returns, irrigating to the end of the field opposite the starting position. There the wheels are put in lateral towing position and the lateral is towed to the starting position. A small tractor is used in the towing. Figure II-14 shows the operation of the towed lateral.

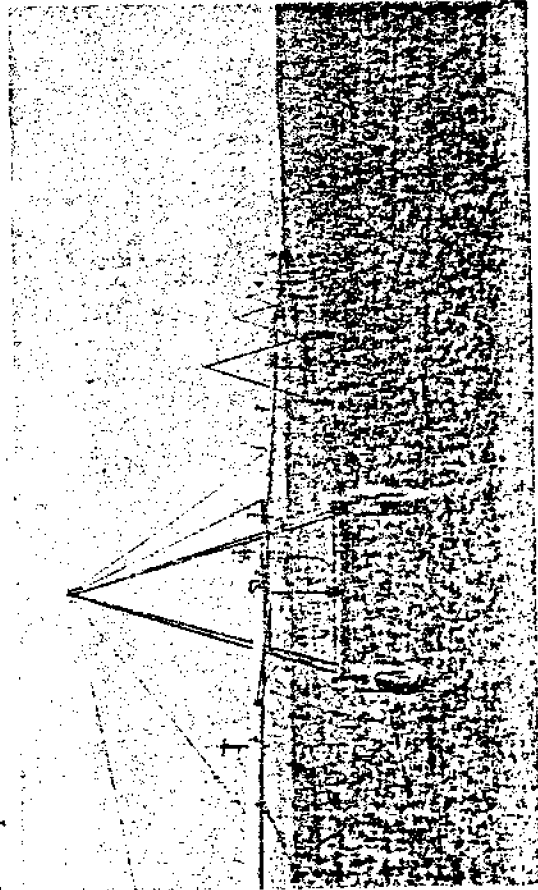


FIGURE II-14.

Straight continuously moving lateral system in end-tow position.

Should the lateral need to be moved farther than the flexible hose length, the hose will have to be disconnected in one outlet and connected to another outlet along the main pipeline. This is usually done by towing the hose with a tractor, but a hose reel illustrated in Figure II-19, Chapter II, is recommended.

This type of system is dependent upon a constant lateral travel speed for uniform water distribution over a field. Some of the factors that affect its ability to maintain constant speed are the same as those that affect the traveler type system and are shown on page 26 of this chapter.

See Chapter VI for additional operating and maintenance suggestions for all parts of the system.

TRAVELER SPRINKLER SYSTEMS

Traveler sprinkler laterals are powered track or wheeled vehicles that tow a high-pressure, flexible hose connected to the water supply main pipeline. The vehicle is towed by a power winch and cable or propelled by its own engine across the field at regular intervals, usually 330 feet apart, irrigating as it moves. The sprinkler is typically of the large volume or boom type, operating at pressures of 80 psi or higher, delivering 300 to 1,000 gpm or more, and covering a wetted diameter of 200 to 600 feet. Chapter II, page 22, has pictures of the traveler system. Figure II-15 shows a second type of traveler.

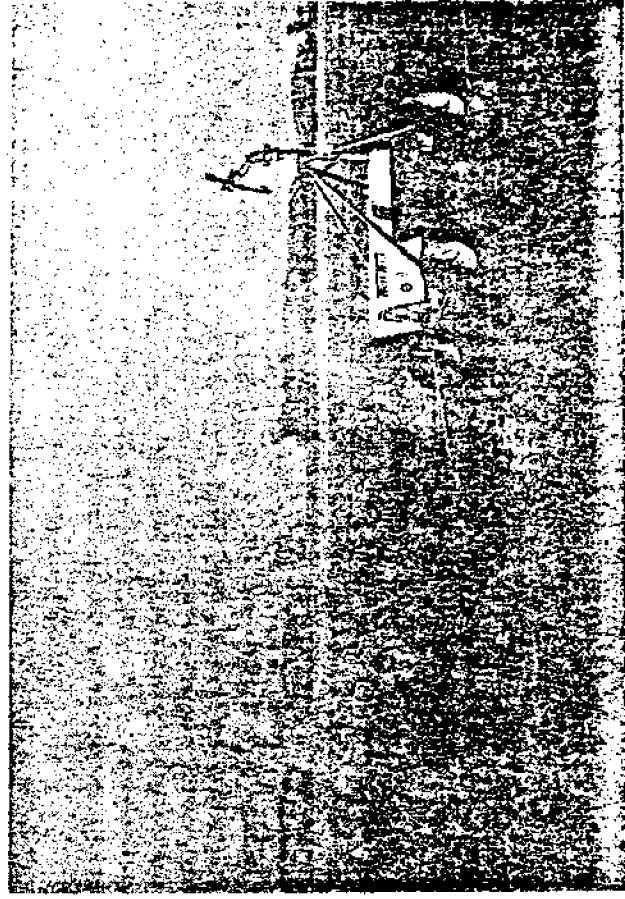


FIGURE II-15.

Traveler system.

Traveler sprinkler laterals may have a long (up to 660 feet), flexible, high-pressure hose to connect the sprinkler on the vehicle to the water supply pipeline. It was the development of large diameter, high pressure, flexible, and wear-resistant hose that gave added impetus to the development of the traveler sprinkler systems. The high-pressure hose is made in 2.5- to 5-inch diameters. It is usually manufactured in one-piece lengths of 330 or 660 feet. The sprinkler travel is limited to twice the flexible hose length before the hose has to be moved from one water supply outlet to another.

Travelers may be self-propelled or moved by an auxiliary engine driving a cable winch stationed at the end of the field, as shown in Chapter II (Figure II-19). Almost all self-propelled travelers use either a water turbine, water piston, or internal combustion engine mounted on the vehicle to power a winch and cable to tow the vehicle. Most vehicles use the stopping point of the vehicle, the cable end being anchored at the stopping point of the vehicle. Travel is usually in a straight line. A reel is used for moving or storage of the flexible hose.

The traveling sprinkler lateral irrigates rectangular strips and is adaptable to a wide range of field sizes and shapes. Initial cost per acre is lower than for most mechanical move systems, and labor requirement is low.

The traveler system can be used on topography ranging from level to rolling and irregular. It can be used in fields that have some obstacles such as powerline poles, trees, and buildings.

Some of the limitations of traveling sprinkler systems are problems caused by heavy textured soils that have very low water intake rates. Variable high winds may distort sprinkler application patterns and reduce pattern uniformity as it does in other system types. The vehicle and high-pressure hose travel lane must be left out of production for some crops. The flexible hose can be damaged if dragged over jagged rocks, barbed wire fencing, and broken glass, but these damages are repairable.

Traveling Sprinkler System Performance depends upon two primary factors: (1) proper system design, and (2) proper mechanical performance of the traveling unit selected.

The proper system design is based on the general steps given in Chapter III for gathering the basic data. The *Traveling Sprinkler System Planning Guide* gives the following planning steps for use of the basic data:

1. Determine the system capacity
 2. Select traveling unit, sprinkler, and flexible hose
 3. Determine the system layout and performance requirements
 4. Determine pressure losses and total head
 5. Calculate the power required
- The capacity needed for a traveler sprinkler system is calculated using the following equation:

$$Q = \frac{453 \times E_p \times A}{E_i H} \quad [7]$$

where Q is in gpm, E_p is peak rate of water use by the crop in inches per day, A is the area irrigated in acres per day, E_i is irrigation efficiency in percent, and H is operating time in hours per day. Figure II-16 is a nomograph for determining traveler system capacity when gross peak irrigation use rate of the crop is determined. Gross peak irrigation use rate is the peak rate divided by the irrigation efficiency.

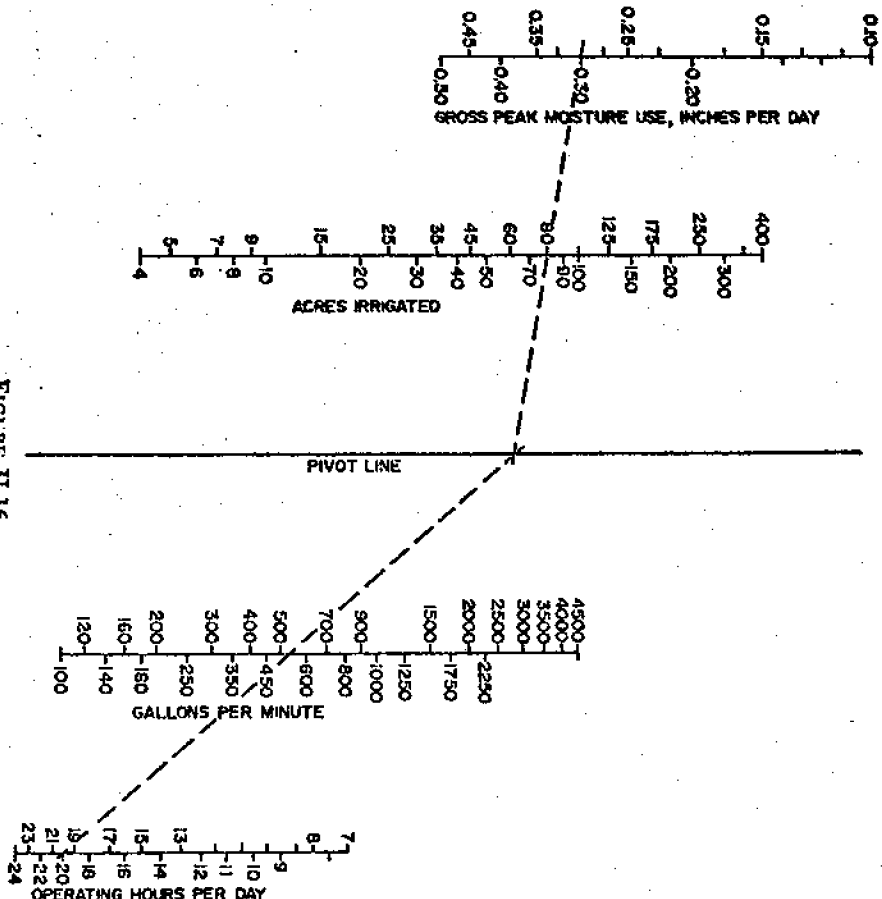


FIGURE II-16. Nomograph for determining traveler system capacity.

The operation of a traveler type sprinkler is interrupted from time to time to move the water supply hose from outlet to outlet on the mainline. Also, the vehicle with sprinkler has to be moved from lane to lane in the field. Approximately 45 minutes is required for a hose and vehicle move. The operating hours in a day will be reduced by

the number of hose and vehicle moves required.

The travel vehicle selected should perform at the needed pumping rate and have the designed travel speed range. Controls to provide uniform speed of travel and positive shutoff at the end of travel are necessary. The manufacturer should supply instructions for proper vehicle operation, maintenance procedures, and repair parts replacement.

The sprinkler should have a capacity equal to that required for the system. The application rate of the sprinkler should not exceed the intake rate of the soil being irrigated. The use of part-circle sprinklers increases the application rate. A half-circle coverage will double the application rate of the same sprinkler with full-circle coverage under the same operating conditions. Some sprinklers need to be operated with part-circle coverage to give even water distribution, a dry path for vehicle travel, or both. The application rate of a sprinkler does not vary with the travel speed of the vehicle, but total depth of water applied does depend upon travel speed.

The use of lower trajectory sprinklers in high wind conditions will get maximum distance of throw and a minimum of pattern distortion. Higher trajectory sprinklers are used for low wind conditions to obtain maximum distance and breakup of stream.

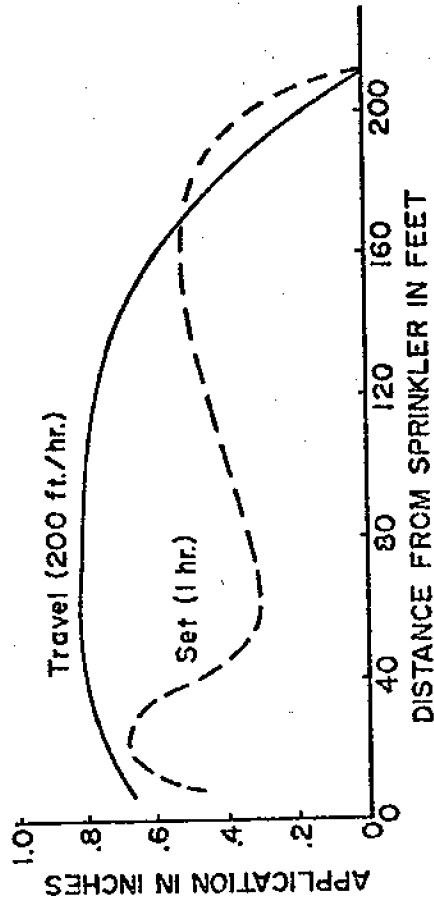


FIGURE II-17. Typical application pattern of traveler system.

The water application rate to the soil from a traveler sprinkler is determined by the sprinkler discharge and the sprinkler pattern, since usually only one sprinkler is involved. See Figure II-17 for an application pattern for a traveler and a "set" sprinkler. An equation used to calculate the average application rate for full-circle coverage is:

$$h = \frac{96.3 Q}{\pi r^2} \quad [8]$$

where h is the average application rate in inches per hour, Q is the sprinkler capacity in gpm, and r is the sprinkler wetted radius in feet. This average application rate is increased if the sprinkler is not operated full circle. The average application rate obtained in Equation [8] is divided by the percentage of a full circle wetted expressed as a decimal.

The selection of hose size for a traveler type system should be made on the basis of the pressure loss that can be tolerated. The capacity of the system can be used as a guide for selecting the diameter from Table II-3. The pressure loss for various size and diameter hoses is shown in Table II-4.

TABLE II-3
Guide for Selecting Irrigation Hose Size
for Traveling Sprinkler Systems^{6,7}

| System average | System-capacity gpm | Recommended | | Standard full length, ft. |
|----------------|---------------------|----------------------------------|---------------------------|---------------------------|
| | | irrigation hose diameter, inches | Standard full length, ft. | |
| Up to 20 | Up to 150 | 2.5 | 330, 500 or 660 | |
| 20 to 40 | 150 to 300 | 3 | 660 | |
| 40 to 100 | 250 to 600 | 4 | 660 | |
| 60 to 120 | 400 to 750 | 4.5 | 660 | |
| 80 to 160 | 500 to 1000 | 5 | 660 | |

TABLE II-4
Estimated Pressure Loss in psi for Irrigation Hose
when Operated at about 100 psi⁸

| | Nominal Inside Diameter, inches | | | | |
|------|---------------------------------|-----|------|------|-----|
| | 2.5 | 3 | 4 | 4.5 | 5 |
| 100 | 1.6 | --- | --- | --- | --- |
| 150 | 3.4 | 1.4 | --- | --- | --- |
| 200 | 5.6 | 2.4 | --- | --- | --- |
| 250 | --- | 3.6 | 0.95 | --- | --- |
| 300 | --- | 5.1 | 1.35 | 0.60 | --- |
| 400 | --- | --- | 2.3 | 1.27 | --- |
| 500 | --- | --- | 3.5 | 2.00 | 1.1 |
| 600 | --- | --- | 4.9 | 2.65 | 1.6 |
| 700 | --- | --- | --- | 3.57 | 2.1 |
| 800 | --- | --- | --- | 4.55 | 2.7 |
| 900 | --- | --- | --- | --- | 3.3 |
| 1000 | --- | --- | --- | --- | 4.2 |

For the layout of a traveling sprinkler system, the prevailing wind direction and slope of fields should be considered. Direction of travel could be at right angles to the prevailing wind direction, and travel across steep slopes should be avoided, if possible. Travel lane width is based on the sprinkler wetted diameter in feet, wind velocity in miles per hour, and sprinkler pattern. Table II-5 shows typical widths based on a percentage of the wetted diameter for various wind speeds.

TABLE II-5
Maximum Spacing for Traveler-type Sprinklers, feet¹

| Sprinkler wetted diameter feet | Percent of Wetted Diameter | | | | | | |
|-----------------------------------|----------------------------|-------------------|-------------------|------------------|------------------|------------------|---------|
| | 50 | 55 | 60 | 65 | 70 | 75 | 80 |
| | Wind over 10 mph | Wind up to 10 mph | Wind up to 10 mph | Wind up to 5 mph | Wind up to 5 mph | Wind up to 5 mph | No wind |
| 200 | 100 | 110 | 120 | 130 | 140 | 150 | 160 |
| 250 | 125 | 137 | 150 | 162 | 175 | 187 | 200 |
| 300 | 150 | 165 | 180 | 195 | 210 | 225 | 240 |
| 350 | 175 | 192 | 210 | 227 | 245 | 262 | 280 |
| 400 | 200 | 220 | 240 | 260 | 280 | 300 | 320 |
| 450 | 225 | 248 | 270 | 292 | 315 | 338 | 360 |
| 500 | 250 | 275 | 300 | 325 | 350 | 375 | 400 |
| 550 | 275 | 302 | 330 | 358 | 385 | 412 | 440 |
| 600 | 300 | 330 | 360 | 390 | 420 | ... | ... |

The average depth of water applied by a traveler system is determined by the sprinkler capacity, spacing between travel lanes, and travel speed. The formula² for calculating the average water depth applied by a traveler is:

$$D = \frac{1.605 Q}{W \times S} \quad [9]$$

where D is the average water applied in inches, Q is capacity in gpm, W is the travel lane spacing in feet, and S is the travel speed of the vehicle in feet per minute (see Table II-6).

Pressure losses, total head, and power required calculations are discussed in textbook Chapter IX.

Operation of Traveler Systems follows the principles of irrigation and maintenance given in Chapter XI, with a few modifications. Figure II-18 shows the system of moving the sprinkler vehicle and cable anchor across a field in the most efficient manner to meet the crop needs.

When moving the hose from one location to the next, a hose reel should be used. The reel should be designed so that the hose may be

TABLE II-6

| Sprinkler gpm | Spacing between travel lanes feet | Depth of Water Applied by Traveling Sprinkler ¹ inches ² | | | | | | | | | |
|---------------|--------------------------------------|--|-----|-----|-----|------|------|------|------|--|--|
| | | Travel Speed feet per minute | | | | | | | | | |
| | | 0.4 | 0.5 | 1 | 2 | 4 | 6 | 8 | 10 | | |
| 100 | 165 | 2.4 | 1.9 | 1.0 | 0.5 | 0.24 | 0.16 | 0.12 | 0.09 | | |
| 200 | 165 | 4.9 | 3.9 | 2.0 | 1.0 | 0.5 | 0.32 | 0.24 | 0.19 | | |
| 200 | 200 | 4.0 | 3.2 | 1.6 | 0.8 | 0.4 | 0.27 | 0.20 | 0.16 | | |
| 300 | 200 | 6.0 | 4.8 | 2.4 | 1.2 | 0.6 | 0.40 | 0.30 | 0.24 | | |
| 300 | 270 | 4.4 | 3.6 | 1.8 | 0.9 | 0.4 | 0.30 | 0.22 | 0.18 | | |
| 400 | 240 | 6.7 | 5.3 | 2.7 | 1.3 | 0.7 | 0.44 | 0.33 | 0.27 | | |
| 500 | 300 | 5.3 | 4.3 | 2.1 | 1.1 | 0.5 | 0.36 | 0.27 | 0.21 | | |
| 500 | 270 | 7.4 | 6.0 | 3.0 | 1.5 | 0.7 | 0.50 | 0.37 | 0.29 | | |
| 600 | 330 | 6.1 | 4.9 | 2.4 | 1.2 | 0.6 | 0.40 | 0.30 | 0.24 | | |
| 600 | 270 | 8.9 | 7.1 | 3.6 | 1.8 | 0.9 | 0.6 | 0.45 | 0.36 | | |
| 700 | 330 | 7.3 | 5.8 | 2.9 | 1.5 | 0.7 | 0.5 | 0.36 | 0.29 | | |
| 700 | 270 | 10.4 | 8.3 | 4.2 | 2.1 | 1.0 | 0.7 | 0.5 | 0.42 | | |
| 800 | 330 | 8.5 | 6.8 | 3.4 | 1.7 | 0.8 | 0.6 | 0.4 | 0.34 | | |
| 800 | 300 | 10.7 | 8.5 | 4.3 | 2.1 | 1.1 | 0.7 | 0.5 | 0.43 | | |
| 900 | 360 | 8.9 | 7.1 | 3.6 | 1.8 | 0.9 | 0.6 | 0.4 | 0.36 | | |
| 900 | 300 | 12.0 | 9.6 | 4.8 | 2.4 | 1.2 | 0.8 | 0.6 | 0.5 | | |
| 1000 | 360 | 10.0 | 8.0 | 4.0 | 2.0 | 1.0 | 0.7 | 0.5 | 0.4 | | |
| 1000 | 330 | 12.2 | 9.7 | 4.9 | 2.4 | 1.2 | 0.8 | 0.6 | 0.5 | | |
| 1000 | 400 | 10.0 | 8.0 | 4.0 | 2.0 | 1.0 | 0.7 | 0.5 | 0.4 | | |

placed on it without first removing the pull coupler. The reel provides a good means of storing the hose in the off-season and is a better method of transporting the hose from one field to another, thus giving a longer hose life.

Constant travel speed of the traveler is required for uniform water distribution over the irrigated area. Some of the factors that affect the ability of a traveler to maintain constant speed are:

1. Hose pull, which varies with size hose, soil type, terrain, and condition of the towpath. Hose pull also varies from zero to maximum in a given travel run.
2. Water pressure and flow rate.
3. Amount of cable buildup on the cable reel varies with the design of the cable drum and must be compensated for in the design of the traveler, or the machine will speed up through the travel run.
4. The characteristics of the power unit on the traveler must be matched to the requirements of hose pull and other factors enumerated above for constant speed operation.

LAND APPLICATION OF LIQUID WASTES*

Sprinkler systems are being used for the application to land liquid wastes from cities, towns, farms, and industrial plants in parts of the United States and abroad. In the United States, over years of experience has led to widespread use, rapidly increased since 1967 with the explosion of Environmental Protection Program and legislation on the national, state, and local levels.

Public Law 92-500 prohibits the discharge of polluted water any river, lake, or underground water supply in the entire nation. Sprinkler irrigation offers an excellent solution wherever location the many economic and technical factors make its use feasible. Private owners are better able to apply the sprinkler technology and are doing so at a much faster rate than public agencies. This is partly because of the scattered locations and special problems of private owners, but particularly because they are under more sure from regulating authorities.

The following is a partial list of potential users of sprinkler irrigation systems for waste-water land treatment:

| | |
|--|--|
| Food processing plants | Paper, hard-board, and related industries |
| Mobile home parks | Hotels, motels, and restaurants |
| "Coin-Op" laundries and car washers | Chemical plants |
| Oil refineries | Metal processing plants |
| Campgrounds and parks | Schools and institutions |
| Golf courses and other recreational facilities | Power plants for dust removal and disposal |
| Cement and ore handling plants | |

Treated liquid wastes are more acceptable for land treatment this method is most widely used. Treatment ranges from screening to primary and secondary treatment, removal of oil, grease, metals, harmful chemicals, pH adjustment, and chlorination.

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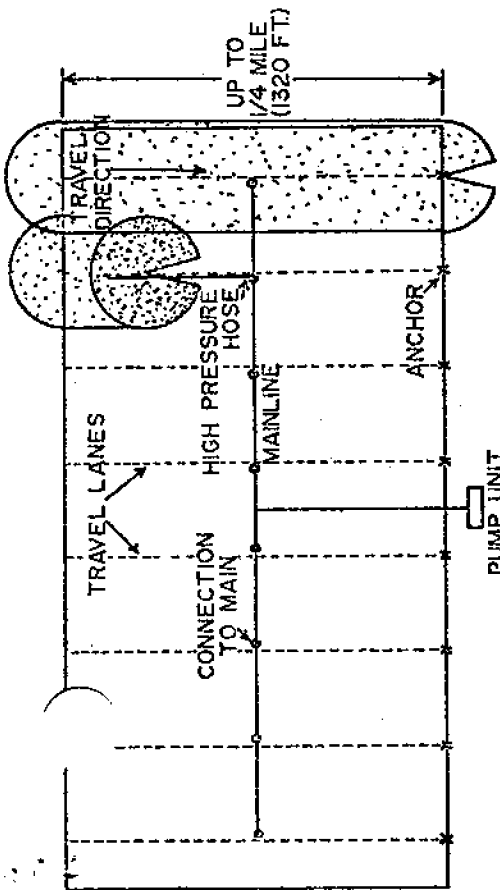


FIGURE II-18.

Operation layout for traveler system.*

Many of the above factors vary by as much as 200 to 300 percent, depending upon location. The capability to handle such wide variations must be included in the design and operation of the traveler.

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