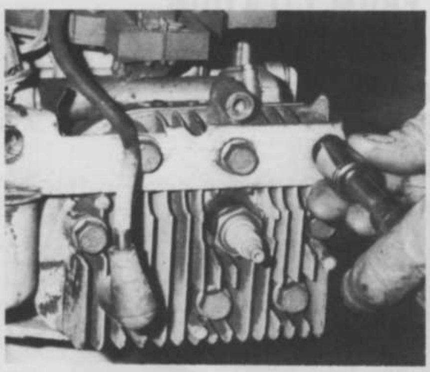
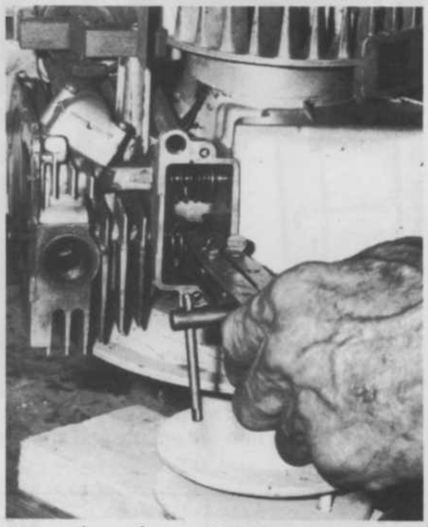
Loss of compression in a small engine is a result of three things: either the cylinder head gasket is leaking, the piston rings are not sealing (engine will also burn oil), or the valves are not seating properly. To check for compression, spin the flywheel clockwise against a compression stroke. Good compression is indicated by a sharp rebound.

If valve grinding is necessary, there are six special tools required, all but two are inexpensive. A valve spring compressor runs about $6.00. A valve refacer can cost approximately $8.00. The wooden handle cup grinder for about $.75. The valve seater costs approximately $60, but there are cheaper versions available. A torque wrench is necessary to retighten the head bolts properly.

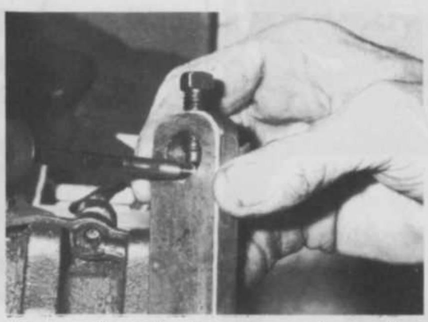


First step is to remove the head bolts. Note the positions of longer and shorter bolts as these must go back into the proper holes. Place the bracket removed to the side, being careful not to stretch the governor spring. Disconnect it if necessary. Inspect the head gasket for gaps that might cause loss of compression.

Remove the cover over the valve springs.

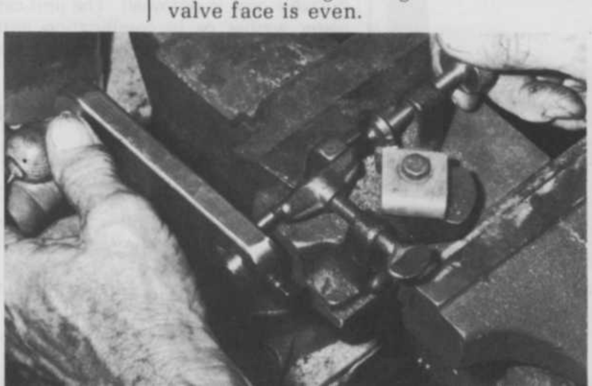


Insert the valve spring compressor over the spring and valve retainer clip. Tighten the tool to compress the spring and tilt it to remove the clip from the end of the valve.



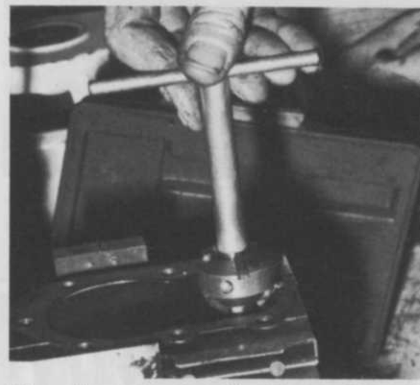
Remove the valve from the engine and insert it in the refacing tool handle as shown. Both seat and valve angles are 45°.

Place it in the refacing tool and tighten the bolt shown on the right until the valve face is against the cutting unit. Turn the handle while tightening the bolt until the valve face is even.



It is also necessary to reface the valve seat. The tool shown is inserted in three pieces. First the pilot.

Then the counterbore.

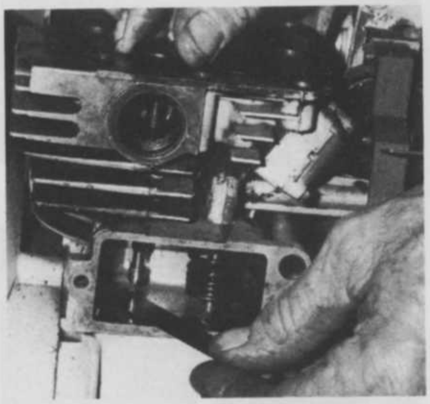


Then the cutter handle. Rotate this unit until the seat is smooth.

It is necessary to lap the surfaces of the seat and face together so that they mate properly. Clean the top of the valve and press the suction cup onto it. Apply grinding compound to the face of the valve.

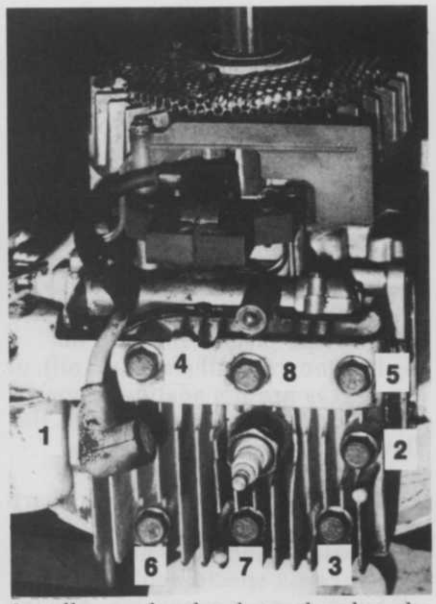
Rotate the wooden handle between your hands while pressing down . . .

. . . until there is a smooth ring ground completely around the valve face and seat.



If much material was removed, it may be necessary to widen the gap between the valve and tappet. Insert the valve into the engine and check with a feeler gauge for .005-.007 for the intake (smaller) valve and .009-.011 for the exhaust. Grind only a minimum at one time until the proper gap is reached.

Replace the valve by inserting the compressed spring into the engine and sliding the valve through the spring and slipping the retainer clip over the end of the valve. Release the spring and remove the tool. Repeat the sequence for the other valve.



Install a new head gasket and replace the head with the proper bolts in the right holes. Tighten the bolts finger tight. Be sure and replace the bracket. Tighten the bolts in sequence, a little at a time, until the proper torque is reached. Tightening one much more than the others will result in a warped head. Proper torque is 140 inch pounds.

SPRINKLER EQUIPMENT FROM IRRIGATION MANUAL

By James A. Watkins, Director of Training, Weathermatic Div., Telsco Industries.

Sprinkler systems for turfgrass and landscaping are classified under three basic types characterized by the kind of equipment utilized:

(1) Spray Systems
(2) Rotary Systems
(3) Quick-Coupling Systems

The cost of the three types of systems is in an approximate ratio of 4 - 2 - 1; spray systems being the most expensive, rotary systems intermediate, and quick-coupling systems the lowest in cost. Thus, a spray system will cost about four times as much as a quick-coupling system, or twice as much as a rotary system; a rotary system will cost about twice as much as a quick-coupling system. Furthermore, each system will fall within a high and low price range of its own due to variations in quality of equipment, piping material selected and the type of property to be watered.

An intelligent selection cannot be based on the relative prices of the three systems alone. For example, a rotary system may meet a budgetary requirement, yet prove totally inadequate for the size and shape of the property or the watering conditions. Application of the three systems overlaps to a great extent, but their adaptability does impose some limitations as to size and nature of the project for which each is best suited.

Before going into the many aspects of sprinkler system design, it is only appropriate that application, relative merits and components be considered first.

SPRAY SYSTEMS

The versatility of spray systems accounts for their extensive use for all types of properties. In spite of their higher cost, spray systems are the most popular because they offer the ultimate in automation, efficiency, convenience, labor savings and aesthetic value.

There are no fixed limitations on the size of project to which spray systems may be adapted, except those imposed by economics.

The sprinkler heads used in this type system discharge a fine, uniform spray. These sprinklers are sometimes referred to as "mist" heads, but this is a misnomer because the spray more nearly resembles small rain-drops.

The following article is an excerpt from the Sprinkler Equipment chapter of the TURF IRRIGATION MANUAL by James A. Watkins and is reprinted with permission of the author and the publisher, Telsco Industries. Other chapters of the TURF IRRIGATION MANUAL include Piping, Hydraulics, Water Hammer, Cross-Connection Control, Pumps, Clean Water, Sprinkler Performance, Plot Plans, Head Layout, Pipe Sizing and Zoning, Rotary System Design, Golf Course System Design and Electrical. In addition, the book has 60 pages of design reference tables.

The author, James A. Watkins, is presently director of training for the Weather-matic Division of Telsco Industries and has more than 40 years involvement with turf irrigation. Copies of the TURF IRRIGATION MANUAL are available for $19.50 each plus $1.25 shipping and handling (U.S.) from Telsco Industries, P.O. Box 18205, Dallas, TX 75218.

Use of the term, "mist head," stems from the characteristics of the spray. The correct amount of water pressure at the sprinkler will form fine water droplets resembling "mist" floating above the spray. Lack of any "floating spray" indicates pressure to the head is below the required amount. In such cases, the coverage is probably deficient. Conversely, abnormally high head pressure causes an excessive amount of "floating spray" which will blow away and increase water costs.

Sprinkler systems of all types with low pressure, and sometimes with excessive pressure, are the direct result of poor system design.

Spray Heads

An exemplary layout of a residential spray system is shown in Figure 1. It illustrates the wide variety of heads in different capacities, spacings and coverage patterns required to provide complete and uniform watering.

POP-UP HEADS. Spray heads for installation in lawns are pop-up types, often referred to as "lawn heads." These heads are installed flush with the turf. A nozzle pops-up to deliver the spray during operation and recedes within the body when inoperative.

Nozzles. The normal area of coverage for pop-up spray nozzles varies from 16 to 30 feet in diameter, in increments of one or two feet, depending on the nozzle or orifice size. Available increments may be more than two feet for large diameter sprays. Shorter radii are available in part circle. Heads are spaced at close intervals (generally 10 to 24 feet apart after making allowances for the required overlap).

Spray nozzles are available in a wide assortment of part-circle patterns. The usual assortment of arcs ranges from ¼ circle to ¾ circle in increments of ⅛ or 1/3. Special arcs for custom system design situations are usually available in 10° increments from 60° to 270°.

Orifices of nozzles are sized to provide a specified radius of coverage and flow at a specified pressure. The specified pressure must be provided by the system designer to obtain proper coverage. If pressure is too low, the spray will not "break-up" into the required fine water droplets

Spray system heads discharge a fine, uniform spray. The correct amount of pressure will cause the appearance of a mist floating above the spray.

necessary to give proper distribution to the entire radius. Also, the specified radius will probably not be attained.

Adjustable full and part-circle nozzle's are also available to the designer. These nozzles feature an adjustment screw for regulating the spray radius. Adjustable nozzles normally are not available in coverage arcs considered special.

Many designers prefer the "fixed-orifice" or non-adjustable nozzle. Pipe-sizing is used to control volume and pressure to the heads. This method insures a "designed-in" balance of sprays throughout the system. This balance is maintained since unknowing persons can't change the flow characteristics of the nozzles with a screwdriver.

Spacing. Head spacings are a matter of choice. Although 20 foot triangular spacing has become more or less standard throughout the industry. There are occasions when a low static pressure or small water supply requires the use of closer spacing.

Each manufacturer provides spray nozzle performance tables indicating water pressure and flow required to obtain coverage. The specifications or tables will also recommend maximum head spacing. Maximum spacing is the distance the heads can be placed apart and still provide the necessary overlap of sprays required for good distribution. Spacing recommendations should never be exceeded. Also, it is cautioned that performance will vary from one manufacturer to another.

Construction. Although there are various popup spray head designs, only that configuration considered *standard* is discussed in this text. The *standard* head has a nozzle flange which seats into the body; see Figure 2. This type construction usually prevents dirt from falling into the head between the nozzle assembly and the body barrel. If dirt enters the head at this point, the pop-up action may be affected, and the resulting malfunction creates unnecessary service problems.

A well designed sprinkler head does not sacrifice material for economy at the expense of performance. There are certain minimum standards that should be met in product design.

The nozzle assembly (functional parts) must contain sufficient weight and clearance within the barrel of the body if it is to recede properly. Otherwise, the advantage of the pop-up is lost in failure

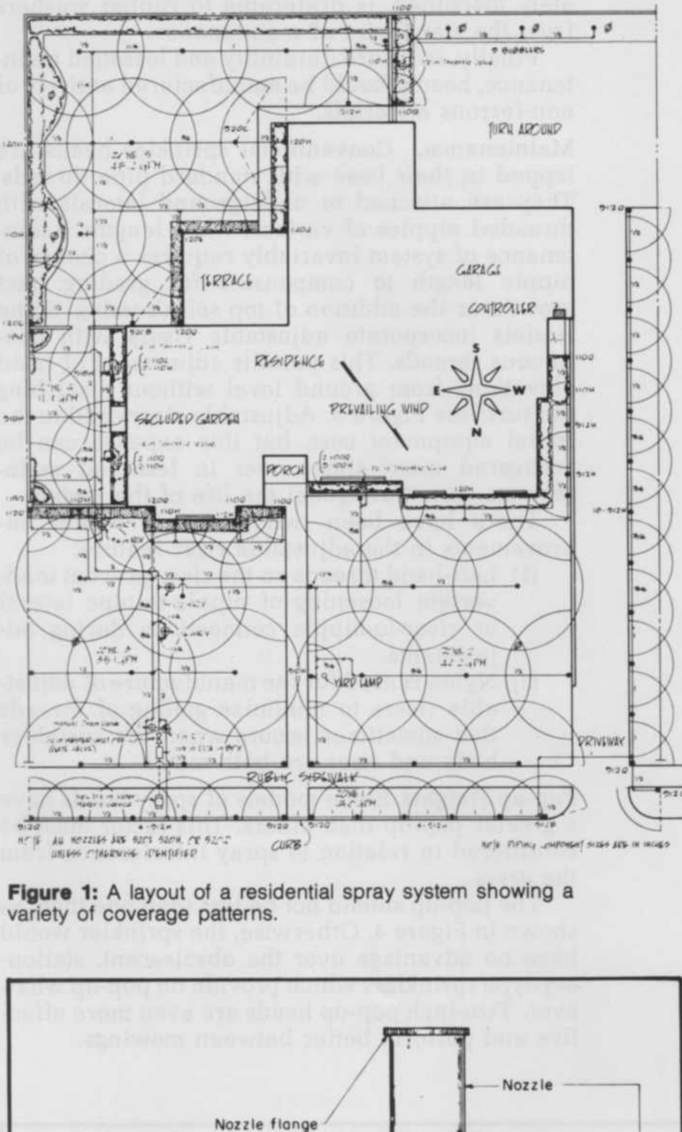


Figure 1: A layout of a residential spray system showing a variety of coverage patterns.

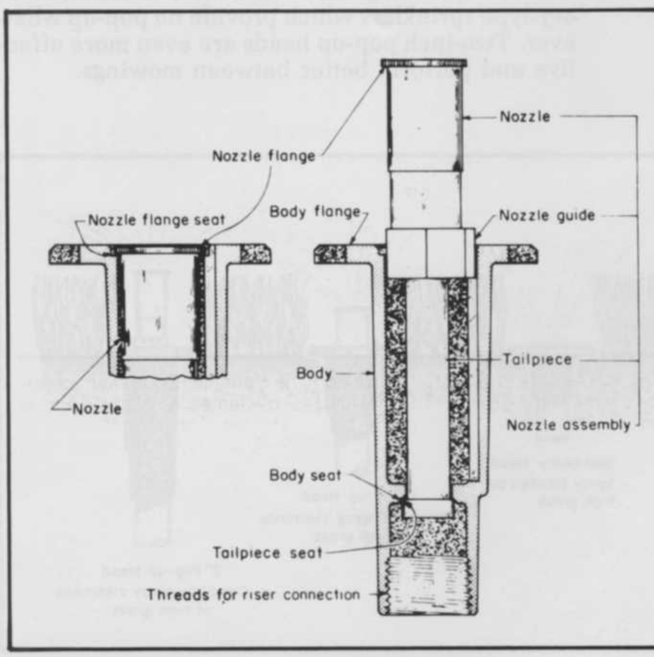


Figure 2: The standard pop-up spray head consists of a nozzle flange which seats into a body.

Sprinkler *from page 25*

to retract. Tailpieces should have an adequate cross-sectional area for passage of water to avoid a high pressure loss through it. If it does not, the head will require an abnormally high inlet pressure.

Direct body-to-tailpiece "seating," if accurately machined, is preferable to rubber washers from the standpoint of maintenance.

Finally, to insure durability and lessened maintenance, heads should be manufactured entirely of non-ferrous materials.

Maintenance. Conventional sprinkler heads are tapped in their base with standard pipe threads. They are attached to underground laterals with threaded nipples of various, fixed lengths. Maintenance of system invariably requires a change of nipple length to compensate for grading, turf growth, or the addition of top soil dressing. Some models incorporate adjustable risers with continuous threads. This permits adjustment of head elevations from ground level without disturbing the turf; see Figure 3. Adjustable risers add to the initial equipment cost, but this expense can be recovered many times over in lessened maintenance costs throughout the life of the system.

There have been two relatively recent improvements in the adjustable riser feature:

(1) Left-hand threads on the riser prevent inadvertent loosening of nipple-to-pipe lateral or riser-to-nipple connections during adjustments.

(2) Nylon is used for the manufacture of adjustable risers to minimize galling of threads that sometimes occurs when the sprinkler body and riser are both metal.

Pop-up Heights. Some models of spray heads have a greater pop-up than others. This factor must be considered in relation to spray interference from the grass.

The pop-up should not be less than one inch, as shown in Figure 4. Otherwise, the sprinkler would have no advantage over the obsolescent, stationary-type sprinklers which provide no pop-up whatever. Two-inch pop-up heads are even more effective and perform better between mowings.

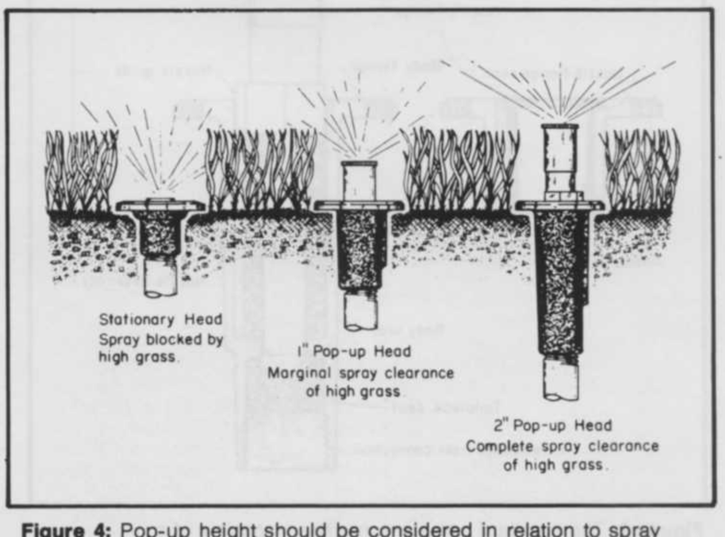


Figure 4: Pop-up height should be considered in relation to spray interference from the grass.

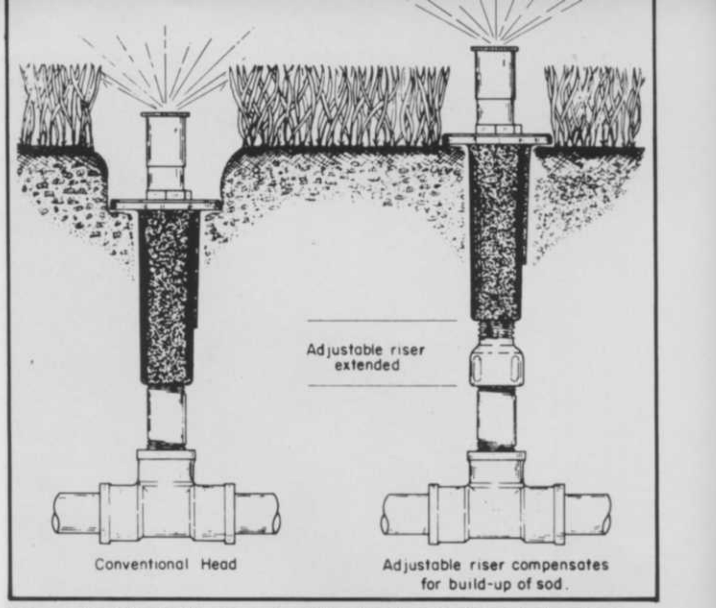


Figure 3: Adjustable risers permit adjustment of head elevation without disturbing the turf.

SHRUB HEADS. Spray heads designed for installation in or above shrubbery and flowers deliver water exactly the same as pop-up sprays. However, shrub heads are made to a much smaller configuration for aesthetic purposes.

Compatibility. The spray of shrub heads should be exactly compatible with pop-up head sprays. This is important because a great percentage of shrubbery can be sprinkled with the same amount of water required for the lawn areas. In these cases, system design can be simplified by blending the sprays of both type heads and operating them together. When systems can be designed this way, unnecessary costs for extra valved zones are avoided.

SPECIAL SPRAYS. A wide choice of spray nozzles and heads with special features is available to the designer.

Low Angle Sprays. Normal spray trajectory is about 30° to 40° above horizontal. Part circle sprays, for both pop-up and shrub heads, are available with a low-angle trajectory of about 10°. The low trajectory reduces the adverse effect of wind drift.

The low-angle shrub spray has proven to be especially beneficial. In fact, most systems installed to day use this feature. Shrub heads should never be installed more than 4 feet above grade in order to assure coverage under the head.

Part-circle, low-angle spray nozzles are sometimes used in pop-up heads. For example, alongside heavily-trafficked sidewalks to minimize the blowing of spray onto the pavement.

Strip Sprays. Spray nozzles for watering long, narrow strips of turf or plantings are available in several different types. These sprays, sometimes called "line" sprays, are generally designed to water 1 to 3 foot wide strips.

Stream Sprays. Some manufacturers offer a spray nozzle that disperses water over the rated coverage area with tiny streams. Generally, it is recommended that heads using stream nozzles be spaced so that streams from each head overlap adjacent heads. With such spacing the streams adequately "crosscross" to provide coverage between the streams. See Figure 5.

Circle 158 on free information card

Sprinkler *from page 26*

Because of their low volume of discharge (and consequent lower rate of precipitation) the stream nozzles are often used on non-sodded banks and berms to minimize run-off and "wash." Also, they are sometimes used in rotary systems to water isolated areas. Because their precipitation rate is closer to that of rotary sprinklers than regular spray heads, they are often operated with the same zone valve.

Because of the very small orifices which form the streams, very clean water is required to avoid an abnormal amount of maintenance to keep these orifices clean.

SPECIAL SHRUB NOZZLES AND HEADS. To further aid the designer, a number of special purpose shrub heads are available.

Short Radii Nozzles. One widely used head is a partcircle spray which features (1) an extremely small radius of about 3 feet, (2) a relatively flat trajectory and (3) low water flow consumption. It can be used for watering "from above" in the normal manner; more often it is used for "flood watering" of narrow, confined areas such as planter boxes. Full-circle sprays available offer a minimum radius of about 6 feet. Head selection will range upward to coverages and flows similar to those available for regular spray heads.Designers may also choose trajectories from "below horizontal" to normal (30° to 40°), depending on model.

Deep Watering. Special heads are required for deep watering of individual shrubs or trees.

One type of special head for this purpose is known as a "Bubbler." It discharges water with an "oozing" effect and is adjustable from very low flows to relatively high flows.

Another type disperses water with small streams. These heads are known to the trade by such names as "spider" and "Jet Irrigator." At low

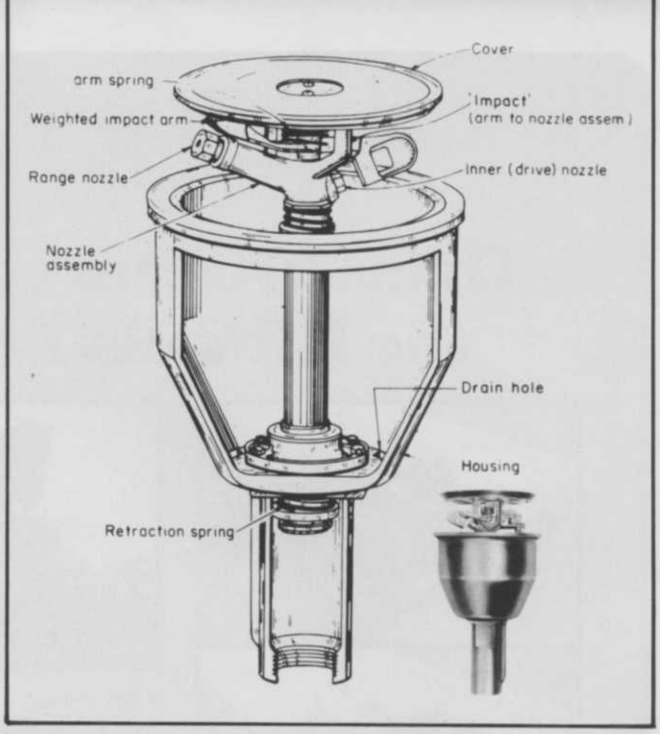


Figure 6: Impact drive rotary sprinklers are rotated by water impacting against a spring-loaded drive arm.

adjustment, the streams reach out only a foot or two, providing an extremely slow soaking action for close-located shrubs. At full-open, the adjustment provides slow precipitation to areas 6 to 8 feet diameter. These heads are available in both full-circle and part-circle models.

Nozzle Adapters. For design versatility, most manufacturers also provide special adapters for compact shrub-mounting of pop-up head nozzles. One pop-up nozzle commonly used in this manner is the "strip" or "line" spray nozzle described previously. This nozzle is excellent for watering narrow planting beds from "above."

EFFICIENCY. Spray systems precipitate water rapidly, at the rate of about one inch per hour; distribution is considered exceptionally uniform when system is properly designed. Since the rate of application is much greater than for other types of systems, the watering schedule can be accomplished in a much shorter period of time. And, since evaporational loss is in direct proportion to the length of operation time, spray systems unquestionably use less water. Automation can help reduce evaporation loss still further by facilitating watering at night. The percentage of water loss due to evaporation is considerably higher for daytime operation.

Watering at night should occur as near to dawn as possible for best results. Avoid evening watering if possible. When watering is done in the evening, the earth remains wet all night. And, overnight dampness provides ideal conditions for growth of moss, fungus, etc.

DESIGN CONSIDERATIONS. Spray systems are zoned and operated in sections or circuits sized to fit the existing water supply, or a new, larger service, if required. The number of heads per circuit is dependent on the flow requirements of each, and the capacity and pressure of the water supply. Thus, the smaller water supply will always

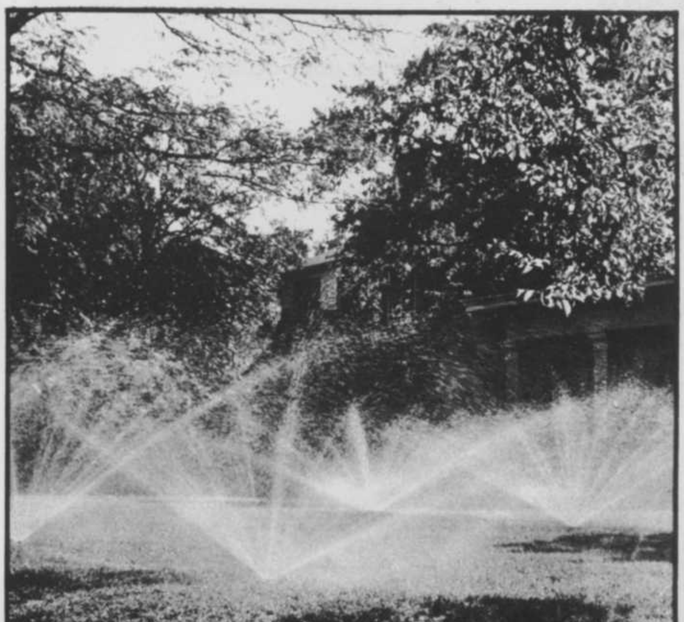


Figure 5: Stream spray nozzles should be spaced so that streams from one head overlap adjacent heads.

Some golf courses have more water hazards than they need.

You thought you were installing a sprinkler system. But now, you're the only course in town with a water hole on every fairway. Bordered by a swamp that's bordered by a bog.

So you reset all the controllers and hope for the best. Then you discover that *was* the best.

The next best is beige-colored greens so hard you can dribble a golf ball on them.

And always there are little surprises. Like sprinklers going off uninvited in the middle of the Invitational.

Like the water bills you get, because your controllers can't tell time very well.

The solution, of course, is a total Rain Bird system. Reliable, precise Rain Bird® controllers that are the standard of the industry. Plus quality, low-maintenance components like our famous sprinkler heads, valves and accessories.

And something you can't get anywhere else . . . the one-of-a-kind Rain Bird expertise that stands behind every job.

So why get trapped by a system that's not up to par. You've already got all the water hazards you need.

® Rain Bird is a registered trademark of Rain Bird Sprinkler Mfg. Corp., Glendora, California.

RAIN BIRD®

Bringing new ideas to life.

necessitate more zones, or circuits, and increase the length of the watering cycle.

Ordinarily, it is impractical to operate all sprinklers in a system simultaneously. The combined flow might create too great a load on the city water main, or the cost of a large enough water service and meter might be prohibitive. On the other hand, too many circuits will prolong the length of watering time beyond reasonable limits. Therefore, if full utility of the system is to be realized, an adequate water supply must be provided in proportion to the property size.

COST FACTORS. The cost of a spray system will vary considerably with such factors as type of equipment, kind of piping, regional labor rates, quality of system design, etc. Due to the many variables, there is no single yardstick that can be applied to cost estimations. For example, a corner lot will cost more than an inside lot of the same size because a greater number of part-circle sprinklers will be needed for perimeter watering.

Part-circle spray heads cost approximately the same amount as full-circles, installed. Therefore, a ½-circle spray head will cost twice as much as a full-circle in relation to the amount of area watered. A ¼-circle would cost four times as much, etc.

Pipe and fittings, which serve as a framework for the system, and labor comprise about 65% of the overall cost. Labor is largely a fixed cost (subject only to the economies that may be realized from efficiency and mechanization). The cost of pipe and fittings will naturally change with the grade of material specified.

The remaining 35% of the cost is made up of sprinkler equipment consisting of heads, control valves, automatic controllers and accessories. Trying to seek savings on sprinkler equipment can very well lead to false economy when realizing that the cheapest equipment can be expected to meet minimum standards of performance, at best. On the other hand, the finest equipment obtainable adds only a nominal amount to the initial cost while offering optimum results with less maintenance expense.

Nozzle	Operating Pressure psi	†Spacing (ft.) Δ	□	Flow gpm	Diameter Coverage ft	Δ ††Precip in/hr
E12 x A11	50	66	61	12.5	102	.31
3/16 x	60	68	63	13.8	105	.33
11/64	70	69	64	15.1	107	.35
	80	71	66	16.4	110	.36
	90	72	67	17.8	112	.38
E13 x A11	50	71	66	15.0	110	.33
13/64 x	60	73	67	16.4	113	.34
11/64	70	76	70	17.8	117	.34
	80	78	72	19.0	120	.34
	90	79	73	20.2	122	.36
*E14 x A11	50	74	68	16.2	114	.32
7/32 x	60	78	72	17.5	120	.32
11/64	70	79	73	18.8	123	.33
	80	81	75	20.1	126	.34
	90	81	75	21.5	126	.36
E16 x A11	50	75	69	19.0	116	.37
1/4 x	60	79	73	20.3	122	.37
11/64	70	81	75	21.7	126	.37
	80	83	77	23.0	129	.37
	90	83	77	24.3	129	.39

Table 1. Typical Rotary Sprinkler Performance Table

ROTARY SYSTEMS

Because of their intermediate cost, rotary systems are quite popular for sizeable projects such as large urban home lots and estates, parks, schools, playgrounds, golf courses, public buildings, factories and offices. The area must be large and generally less confined by sidewalks, buildings, etc., since rotary systems are not as flexible as spray systems.

Rotary sprinklers utilize slowly-rotating, high-velocity streams to distribute water over relatively large circular or semi-circular areas. Depending on the model of sprinkler, one to several streams are used. Coverages range from about 40 feet to over 200 feet in diameter.

ROTARY SPRINKLER HEADS

Rotary heads, like spray heads used in turfgrass areas, are pop-up with the head being completely concealed in the ground except for the coverplate, which is exposed at ground level. The nozzle portion pops-up to sprinkle and recedes within the sprinkler housing when inoperative.

During operation, water under pressure flowing through the heads drives any one of several types of mechanisms to rotate the nozzle assembly. Rotary head drives are named to describe the basic component providing the rotational drive force. Most well-known are the "impact" drive and "gear" drive, which are described in the following text along with other mechanism types in use today.

IMPACT DRIVE ROTARY HEADS. The impact drive rotary sprinkler employs a weighted, spring-loaded drive arm to provide the force to rotate the nozzle assembly. The sprinkling stream deflects the arm sideways and the spring pulls the arm back to the nozzle assembly and into the path of the stream. As the drive arm completes each swing cycle it impacts against the nozzle assembly rotating it slightly. See Figure 6. Most models of this type of sprinkler are available in both full-circle and part-circle.

Adjustable arcs. Part-circles are infinitely adjustable for degree of arc to be watered. Adjustment, depending on model, can be as much as from 20° to 340°. Some models are known as "combination" sprinklers because disengagement of the trip-pin of the reversing mechanism converts a part-circle to a full-circle.

Nozzling. Full-circle, pop-up impact sprinklers generally utilize two opposed nozzles; a "range" nozzle and an "inner" nozzle which make possible larger diameters of coverage. Long streams can't provide "breakup" of the stream into the small water droplets required to give distribution for the entire length. So, the "range" nozzle provides distribution at the outer areas of coverage diameter. And, the "inner" nozzle provides the distribution from the head to where the "range" nozzle begins its distribution.

Part-circle impacts also utilize two nozzles. However, the nozzles both face the same direction. Only one nozzle is utilized on some smaller im-