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AUTOMATED AND MANUAL LAYFLAT TUBING FOR IRRIGATION AND CONVEYANCE

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/flat tubing has been used for a number of years for irrigation (Hansen, 1954; Lauritzen, 1957; mphreys and Lauritzen, 1964). Most tubing presently used in the United States is a low-cost, thin-ll, non-reinforced tubing with a one- or two-year life expectancy. Layflat tubing is used both for tribution to individual furrows, when equipped with outlets, and for conveyance. It has many of advantages of rigid surface irrigation pipe and can be used as an alternative to rigid surface pipe most situations. It is particularly well-suited for dividing fields with long irrigation run lengths into orter run lengths.

e tubing described in this paper is uniquely constructed with an interior membrane and tribution outlets such that one tube can serve two functions--water conveyance and irrigation. nen a single gated pipeline or length of tubing is used for a number of consecutive irrigation sets, e group of gates must be closed and another group opened at each irrigation set change. This quires considerable labor which can be almost eliminated by using the tubing described in this per (a patent is pending).

SYSTEM DESCRIPTION

ping

ile any suitable tubing material can be used, vinyl with a polyester reinforcing fabric is presently ed. Other materials are also being tested to determine which would be the best for this plication. The tubing contains ultraviolet inhibitor so that the system is considered semipermanent n an expected life of approximately 5 to 8 years. The unique feature of the tubing is its rication. It is fabricated from two sheets of material whose edges are heat-sealed along their gth so as to form a tube with one of the sheets forming an interior membrane, as illustrated in . 1. Flow outlets are made on one side of the tubing, as shown in Fig. 2. These consist of a flow-ulating slide and a mating pocket which is sealed to the tubing. A round orifice or flow opening is nched through both the pocket and the tube. The slide is presently cut from a semi-rigid sheet of mm (0.03 in) thick high-impact styrene. A common plumbing gasket cemented to one side of the le forms a seat around the orifice when the slide is fully inserted into the pocket. For flow ustment, the slide is positioned so that the gasket is on the outside as shown in Fig. 2. This type v outlet is used to make the tubing portable so that it can be more easily rolled up and moved. nventional gates for irrigation tubing are quite bulky so that it is difficult to roll up long lengths of ing. The slides are easy to make and the material cost is less than 10 cents each.

ping Connectors and Accessories

e semipermanent layflat tubing system must be dismantled if it is to be moved. To accomplish , connections were designed so that valve and coupler fittings can be easily disconnected from tubing.

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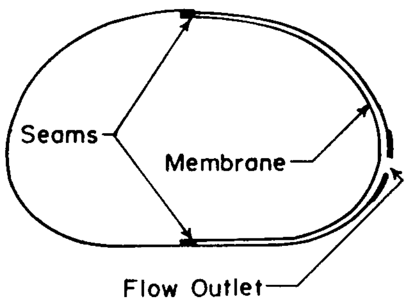

Fig 1 Cross section diagram of layflat tubing illustrating its fabrication with an internal membrane.

Fig 2 Flow outlet on the side of layflat tubing.

Couplers

A tubing coupler consists of a section of aluminum or PVC surface pipe about 0.3 m (12 in) long with an interior membrane whose edges are cemented to the inside walls of the pipe on each side. Thus, when the membrane inside the coupler is attached to the corresponding tubing membranes at each end by fasteners, a continuous membrane, which extends through two lengths of tubing, is constituted.

Both zipper and Velcro[**]-like fabric fasteners are used to connect the interior membrane of the tubing to that of a coupler or valve. One matched fastener piece is cemented to the end of the membrane inside of a tube while its mating fastener is attached to the corresponding membrane inside of a coupler or valve. The end of the tubing membrane, with the fastener material attached, is cut away from the tube wall on each side so as to form a tongue-like membrane segment which extends about 5 cm (2 in) into the end of the coupler or valve body. The end of the tube is folded back to allow the membrane segment to extend into the pipe section where the two mating fasteners are connected, as shown in Fig. 3. The end of the tube is then unfolded and slipped over the coupler or valve pipe section and clamped. The tubing membrane is attached at both ends of a coupler and at the downstream end of each valve. A zipper connector is shown in Fig. 4.

Diverter valves also serve as couplers since they are installed in the system between two consecutive lengths of tubing that constitute two irrigation sets. The tubing is attached to the upstream end of each valve so as to form a terminus for the upstream distribution channel of the tube when in its irrigation mode. To do this, the tube's interior membrane is cemented to the discharge side of the tube (the side with the flow outlets) at its downstream end and then the tube is slipped over and clamped to the upstream end of the valve body.

Valves

Diverter valves are needed to divert the flow of water from one side of the interior membrane to the other. This changes a tube's operating mode from conveyance to that of irrigation or vice versa. Two different styles of diverter valves are being tested. The valve bodies for both are usually made from short sections of aluminum tubing about 0.6 m (2 ft) long which have the same outside diameter as surface irrigation pipe. The valves can also be made from PVC pipe containing U.V. inhibitor. The edges of an interior membrane of one-half circumference net width are cemented to the inside walls of the downstream portion of each valve body.

Style 1 valve. The upstream end of the membrane for the first style valve is attached to a flat stainless steel spring band mounted inside of the valve body with its ends diametrically opposite

[**]Names of products or companies are shown for the benefit of the reader and do not imply endorsement or preferential treatment of the product or company noted.

Fig 3 Interior membrane of a tube connected to that of a coupler with a Velcro fabric fastener.

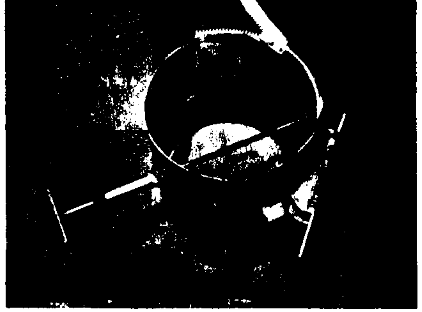

Fig 4 Style 1 valve with a zipper connector for the interior membrane.

each other as illustrated in Fig. 5. The ends of the spring band are attached to stainless steel hinges which are mounted in anchor blocks attached to the wall of the pipe. Manual and semiautomatic versions of the valve use a shifting rod attached to the center of the steel band as shown in the figure to shift the band from one side of the valve to the other. Thus, the end of the membrane, which is attached to the band, is moved from side-to-side to divert water from one side of the membrane to the other. A 9.5 mm (3/8 in) stainless steel pipe is used for the shifting rod. This fits over a 6 mm (1/4 in) brass guide rod, as shown in Fig. 5, which has one end attached to one side of the valve body.

Style 2 valve. The second style valve uses a bail in a hoop or alligator-jaw configuration, as shown in Fig. 6, to shift the membrane from side-to-side. An 11 mm (7/16 in) brass shifting rod attached to the bail is used to shift the bail in the manual and semi-automatic versions of the valve. Because the outer end of the bail swings in an arc, it is not aligned straight with the axis or line-of-motion of the shift rod throughout its travel path. Therefore, a 2.4 mm (3/32 in) diameter, stainless steel spring wire is attached to the end of the shift rod and to the bail, Fig. 7, to accommodate the lateral movement of the bail along the arc of its travel path. The bail consists of two flat pieces of aluminum approximately 12 mm (1/2 in) wide riveted together with the tubing membrane and rubber seals clamped in-between. The shape of the bail conforms approximately to one-half of an ellipse and makes an angle of 25° with the side of the valve body at either end of its travel path.

Semiautomated valves. The manual valves of both styles are semiautomated by adding return springs, latch, and an electric solenoid operator to release the shifting rod from its manually-reset extended position. This is accomplished as shown schematically in Fig. 7. A shift rod latch through which the shift rod travels consists of a modified quick-connect air hose coupling. Small steel balls fit into a detent groove on the shift rod to hold the rod in its extended position. A sliding collar on the air hose coupler is moved about 3 mm (1/8 in) by an electric solenoid (not shown in Fig. 7) to release the shift rod. The shift rod is moved to its other divert position by two small constant-force springs attached to the rod handle as illustrated in Fig. 7. The 6 VDC solenoid can be controlled by any timer/controller which can provide the appropriate energizing current.

Automated valves. Both style valves can be fully automated by using a 1.2 mm (3/64 in) diameter, 7 X 19 stranded, stainless steel cable instead of shifting rods to shift the membrane from side-to-side. The cable is pulled from side-to-side by a 12 VDC gearmotor, Fig. 8. Number 25 roller chain attached to the ends of the shifting cable is driven by a sprocket on the motor's output shaft. The motor's rotational direction is determined by the controller.

A simpler alternative for automating the style 2 valve is to attach a 12 VDC gearmotor directly to one side of the bail shaft where it extends through the wall of the valve body. For this, the bail is

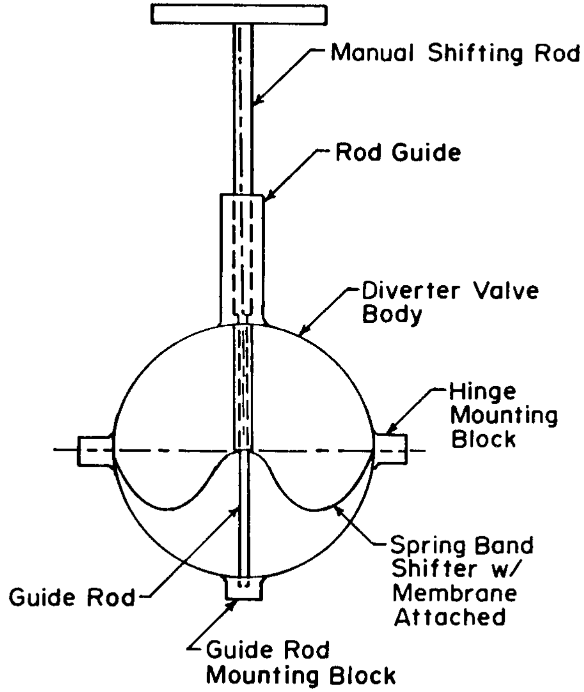

Fig 5 Cross section diagram of a style 1 diverter valve valve with a stainless steel, spring-band, shifter.

designed stronger so as to withstand the shifting torque which is applied to only one side of t
A valve with a commercial controller mounted in this manner is being tested.

The automated valves are well suited for intermittent or surge irrigation and this is the only wa
have been used. Because the labor requirements for this layflat tubing system are so small, t
justifiable reason, in most cases, to use fully automated valves is to utilize the surge concept.

Tee valves. A nonautomated diverter valve in a tee configuration is shown in Fig. 9. Although
part of the layflat tubing system, it is described here because its interior workings and operatio
similar to the other manual diverter valves. The valve has an interior membrane which is shifte

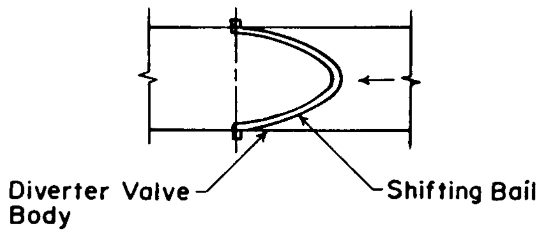

Fig 6 Schematic diagram (plan view) of a hoop-shaped bail shifter for style 2 diverter valve.

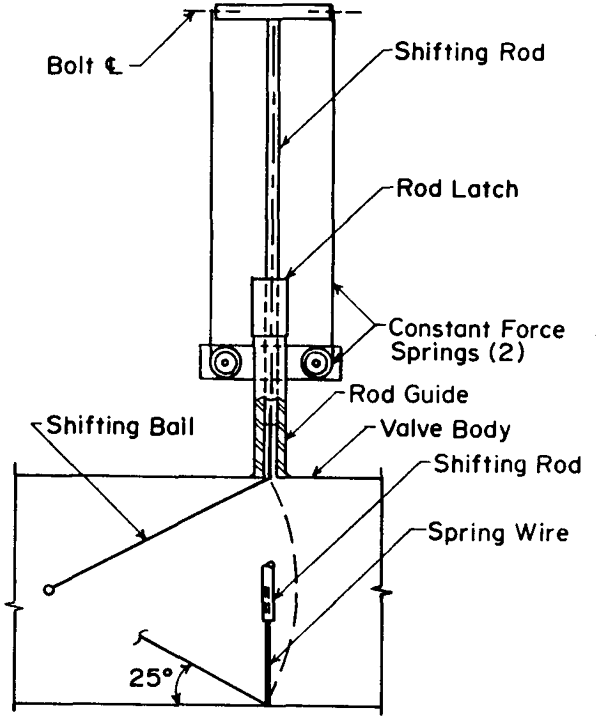

Fig 7 Cross section diagram of a style 2 semi-automated diverter valve.

as to cover the side outlet in the flow-through mode. In the divert mode, the side outlet is uncovered and the membrane forms a closure for the downstream leg of the pipe tee, Fig. 9. The same types of shifting means are used as described previously for the other valves. The upstream end of the interior membrane is cemented to the shifter (either a bail or a stainless steel band) while its sides are cemented to the interior walls of the tee. The downstream end of the membrane is clamped to one side of the pipe to form a pipe closure. The valve is operated by just pulling or pushing a shift rod to change valve positions or modes.

This valve is designed for use with conventional thin-wall, non-reinforced layflat tubing. In a typical installation, the tee is installed in the tubing at a junction of conveyance tubing at the side of the field with tubing placed laterally across the field for irrigation. The diverter valve is used to either bypass the water supply to downstream sections of tubing or to divert the flow to the lateral tubing for irrigation.

Controllers

The semiautomated diverter valves presently used are controlled by mechanical timers which are also used to control irrigation gates (Humpherys and Fisher, 1987; Humpherys, 1988). These timer units use capacitor discharge to energize electric solenoids which in turn release latches on the valves. However, any timer or controller can be used which provides the appropriate energizing current for the solenoids. The valve's latch mechanism can also be readily modified to accommodate an electric motor-driven latch release.

Two motorized valves being tested are controlled by experimental electronic controllers previously developed for surge irrigation (Fisher and Humpherys, 1983). A latching relay is used to interface

Fig 8 Automated style 2 diverter valve used for surge irrigation with an electric motor operator.

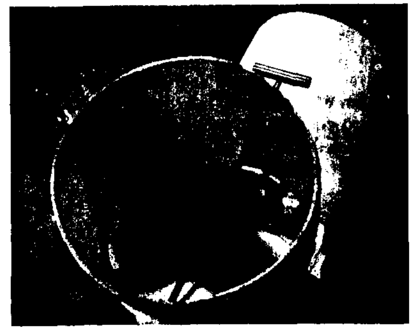

Fig 9 Manually-operated tee valve for layflat tubing.

the controller to the valve's motor since the controller was designed to operate solenoids. One automated diverter valve is controlled by a commercial surge irrigation controller.

FIELD TESTS

The layflat tubing system was tested in Idaho on two farmer fields and on a field plot at the Resea[rch] Center during 1989. The tubing on one farm consisted of 98 m (325 ft) of 300 mm (12 in) diamete[r] and 182 m (600 ft) of 250 mm (10 in) diameter tubing for six irrigation sets. This was the first actu[al] field test of the system and it replaced an open ditch and siphon tubes. Both manual and automated valves were used. The system in general worked well except for the usual first season startup problems. Some of the tubing cement failed after being immersed in water for a time, and a different cement had to be used. All of the valves were style 1,and these require very close tolerances in fitting the spring band inside the valve body. Facilities for maintaining the required tolerances were not available and some of the valves leaked. With adequate control in commercial production, this should not occur. Consequently, the style 2 valves with a bail-type diverter mechanism were developed and used for the 1990 tests. The velcro fabric fasteners performed satisfactorily. Tubing for the other farmer test was 200 mm (8 in) diameter and 137 m (450 ft) long with three manual valves. This system worked well except for two leaking valves whic[h] were replaced for the 1990 tests. The tubing test on the research plot consisted of one set with a[n] automated valve. The object of this test was to evaluate the performance of the valve for surge irrigation. The valve operated without any failures during the five irrigations that it was used. It cycled water alternately between two half-sets during each irrigation.

In operation, when the tubing is shifted from the irrigate mode to the conveyance mode, there is a time lag for the change to occur because the discharge channel of the tube must be emptied through the flow outlets before water can pass through the conveyance side of the tube. This requires about 1 to 3 minutes depending on the stream and flow opening sizes. This time lag is negligible when changing from the conveyance to the irrigation mode as when irrigating in the upstream direction from the downstream end of the line. Therefore, operationally, sequencing set changes from the downstream set to the upstream set is preferred. The lag time will not usually b[e a] problem, but must be considered when operating the motorized valve for intermittent applications where irrigation is alternated between two sets. Provision can usually be made in the supply syst[em] to spill part of the flow if necessary during the short 1 to 3 minute time period required to make th[e] change. Enough water remains in the tubing after an irrigation to prevent movement by the wind. Unless irrigation begins at the time the tubing is laid out, some water must be put into the tube to hold it in place.

Since the interior membrane is not needed for the irrigation set at the downstream end of a line, a conventional gated pipe can be used for this set if desired. A length of tubing can also be used i[f] end is closed. This can be done by raising the end of the tubing to a height greater than the hydraulic grade line or pressure head of water in the tube or by clamping it onto a short section of pipe with the membrane to one side to close the irrigation channel of the tubing, the same as on the upstream side of a valve.

The system with manually-operated valves was very useful even without automation and allowed the irrigators to change irrigation sets by just pulling a handle. The irrigators reported that this saved them considerable time and labor, particularly with the large system that eliminated an open ditch and siphon tubes.

SUMMARY AND CONCLUSIONS

Layflat irrigation tubing can be used as an alternative to rigid surface pipe in most situations. When a single length of gated pipe or tubing is used for a number of consecutive irrigation sets, the gates or flow openings of one set must be closed and those of another set opened at each irrigation set change. This requires considerable labor which can be greatly reduced by using the tubing described in this paper. This tubing is uniquely constructed with an interior membrane and distribution outlets such that the tubing can serve two functions--water conveyance and irrigation.

Diverter valves were developed to direct water flow in the tubing either to one side of the membrane for irrigation through flow outlets, or to the other side of the membrane for conveyance to the next downstream set(s). Irrigation sets can be changed manually by merely pushing or pulling a shifting rod to change the valve's operating mode from conveyance to that of irrigation or vice versa. This is equivalent to manually opening and closing the flow outlets for two irrigation sets. The manual valves were readily converted to semiautomatic operation by adding return springs, latch, and a release mechanism for timer control. Surge or intermittent irrigation is feasible with automated diverter valves controlled by surge irrigation controllers. These valves, which were operated by battery-powered 12 VDC electric motors, performed well during the field tests.

Valve and coupler fittings were designed to be easily assembled and disassembled for portability. This was accomplished by using Velcro-like fabric fasteners or zippers to connect the interior membrane of the tube to that of a valve or coupler. Flow outlets consist of a pocket attached to the side of the tubing with an orifice and a mating slide to adjust the flow. A patent on the layflat tubing and its components is pending.

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