May 27, 1969 F. J. SMITH, JR., ET AL 3,446,434

IRRIGATING APPARATUS CONNECTOR ASSEMBLY

Filed April 26, 1968

Sheet 1 of 12

FIG. 1

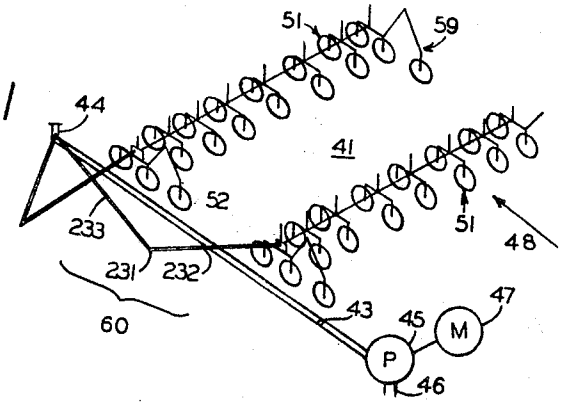


FIG. 2

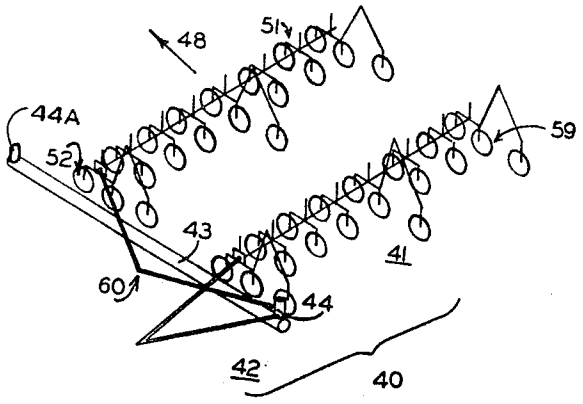
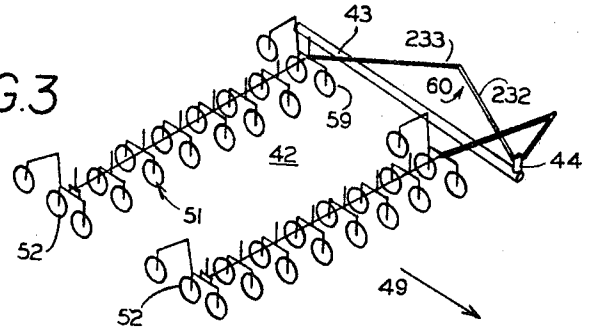


FIG. 3



INVENTOR.
F. J. SMITH JR.
& J. L. SMITH

BY Ely Silverman
ATTORNEY

May 27, 1969 F. J. SMITH, JR., ET AL 3,446,434

IRRIGATING APPARATUS CONNECTOR ASSEMBLY

Filed April 26, 1968

Sheet 2 of 12

FIG. 4

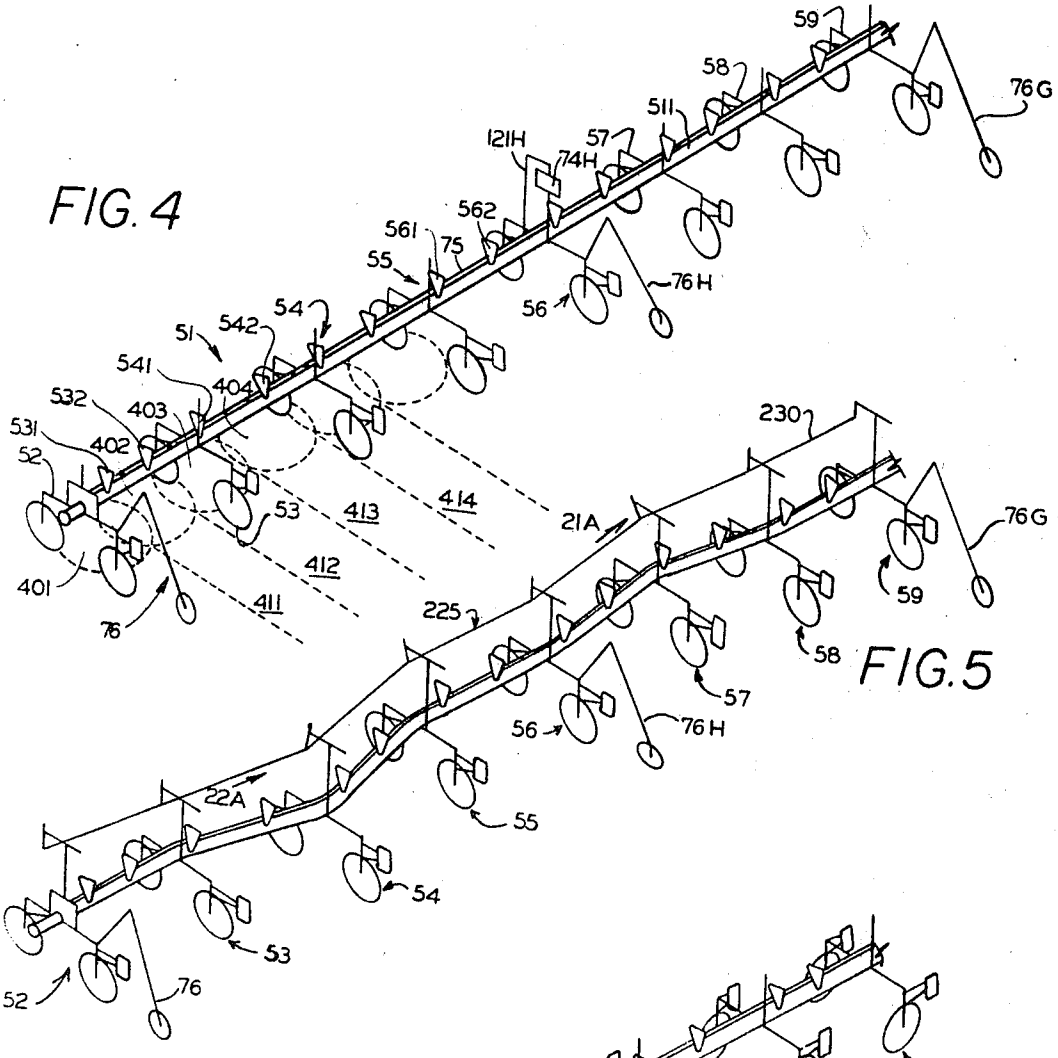
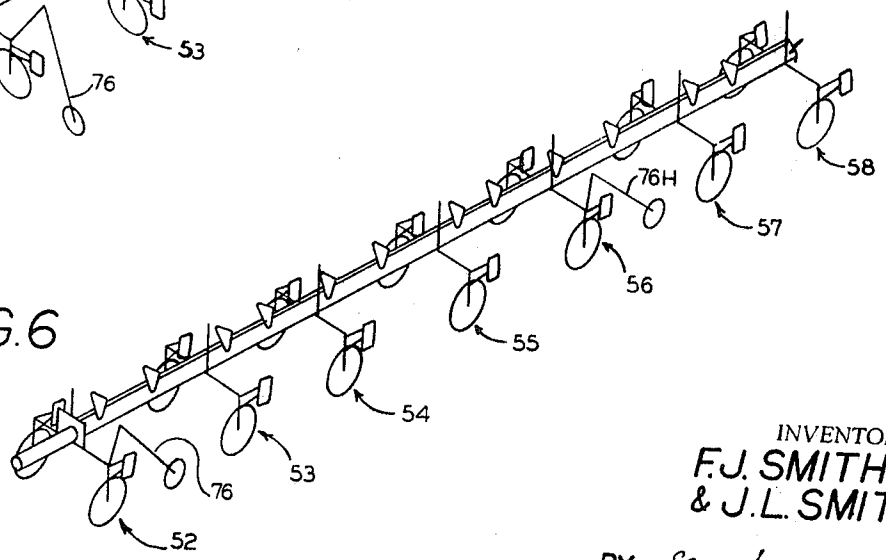


FIG. 5

FIG. 6



INVENTORS
F.J. SMITH JR.
& J.L. SMITH

BY Ely Silverman
ATTORNEY

May 27, 1969 F. J. SMITH, JR., ET AL 3,446,434

IRRIGATING APPARATUS CONNECTOR ASSEMBLY

Filed April 26, 1968 Sheet 3 of 12

FIG. 7

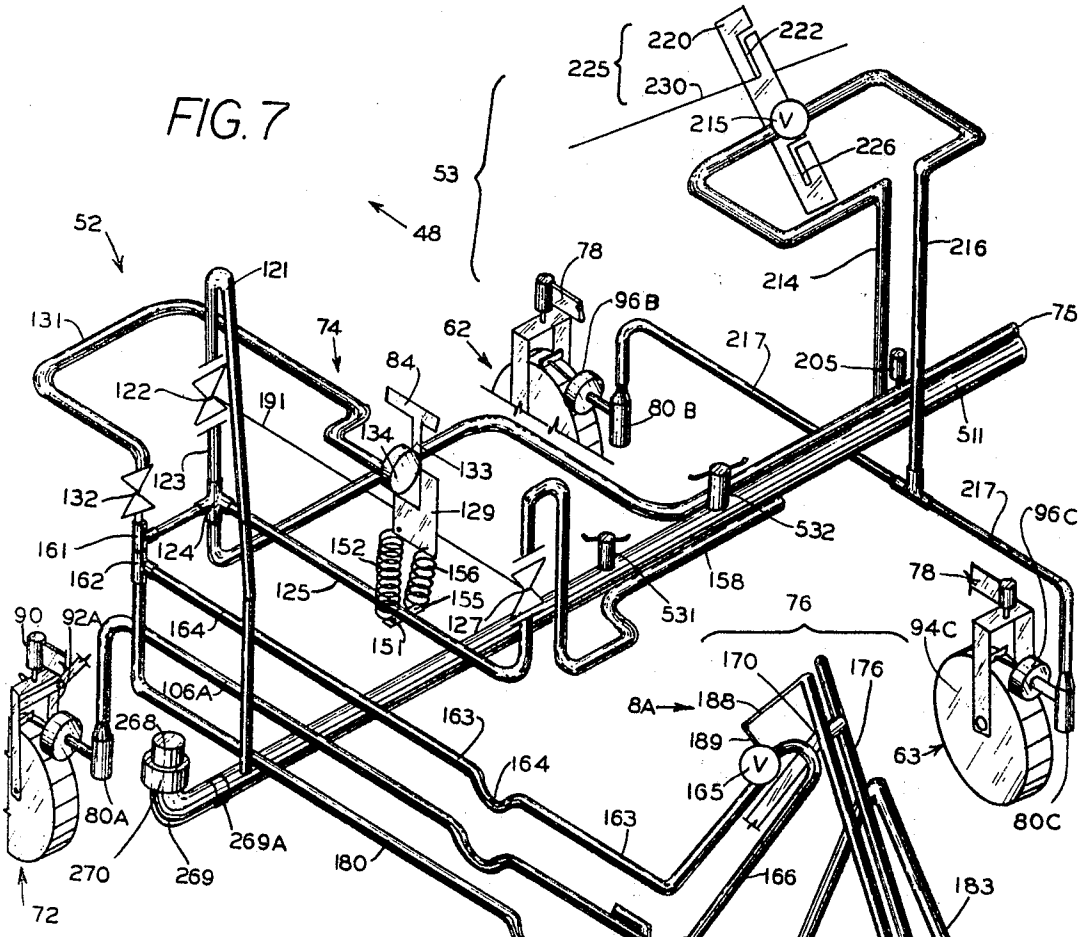
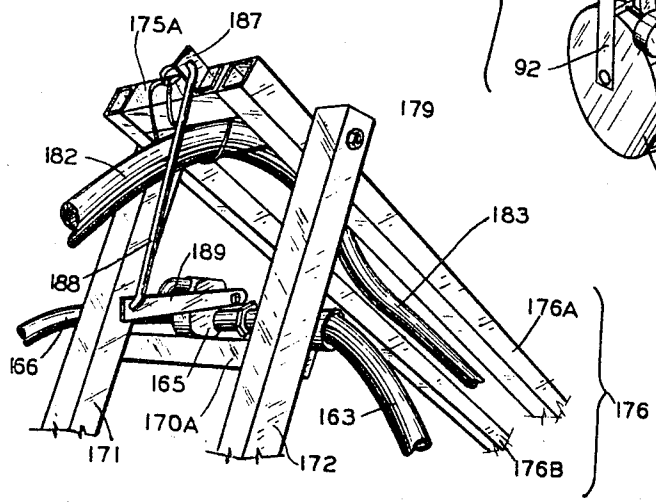


FIG. 8



INVENTORS
F. J. SMITH JR.
AND J. L. SMITH

BY Ely Silverman
ATTORNEY

May 27, 1969 F. J. SMITH, JR., ET AL 3,446,434

IRRIGATING APPARATUS CONNECTOR ASSEMBLY

Filed April 26, 1968 Sheet 4 of 12

FIG. 9

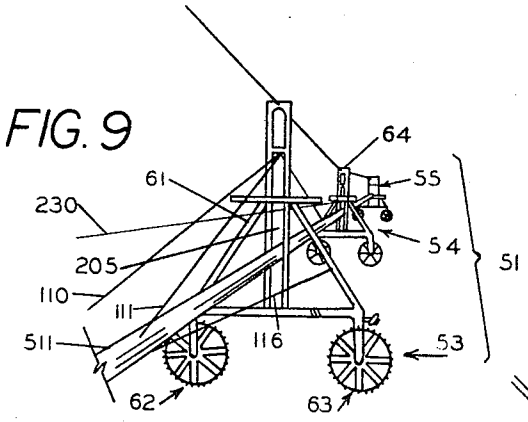


FIG. 10

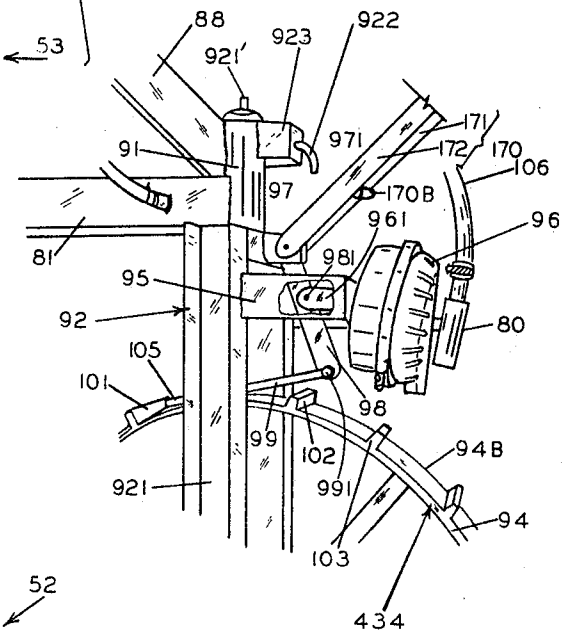
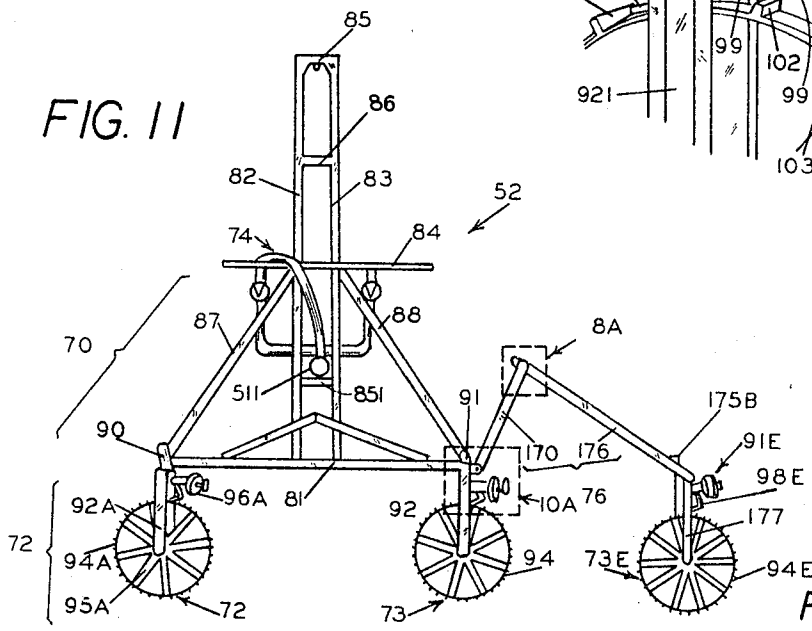


FIG. 11



F. J. SMITH JR.
AND J. L. SMITH
INVENTORS

BY

Ely Silverman
ATTORNEY

May 27, 1969 F. J. SMITH, JR., ET AL 3,446,434

IRRIGATING APPARATUS CONNECTOR ASSEMBLY

Filed April 26, 1968

Sheet 5 of 12

FIG. 12

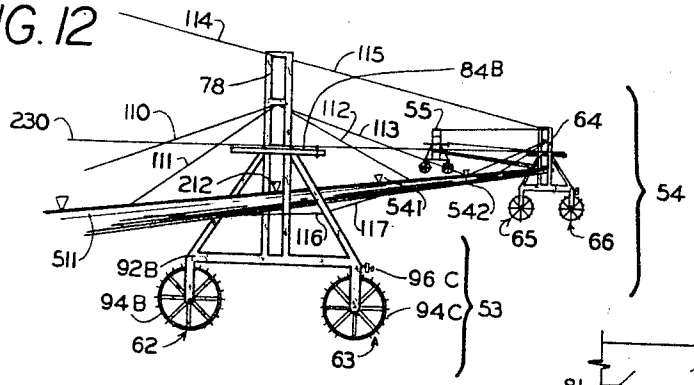


FIG. 13

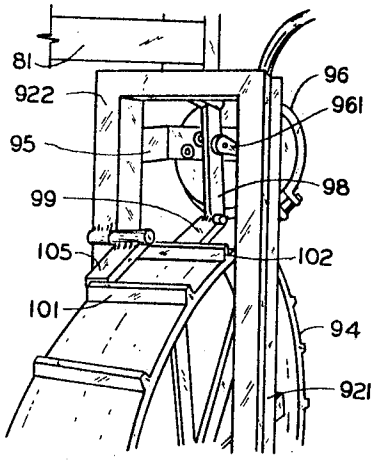
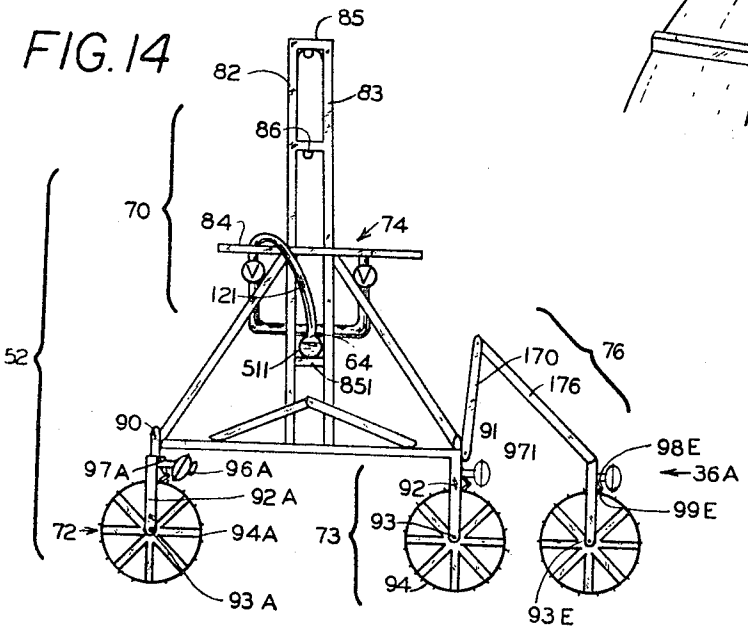


FIG. 14



INVENTORS
F. J. SMITH JR.
& J. L. SMITH

BY Ely Silverman
ATTORNEY

May 27, 1969 F. J. SMITH, JR., ET AL 3,446,434

IRRIGATING APPARATUS CONNECTOR ASSEMBLY

Filed April 26, 1968 Sheet 6 of 12

FIG. 15

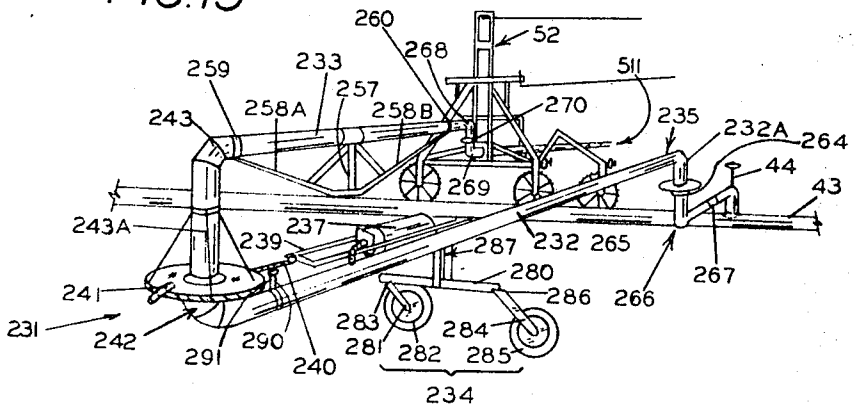


FIG. 16

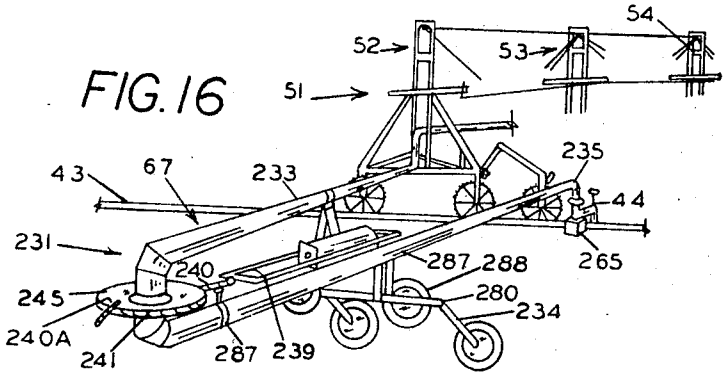


FIG. 17

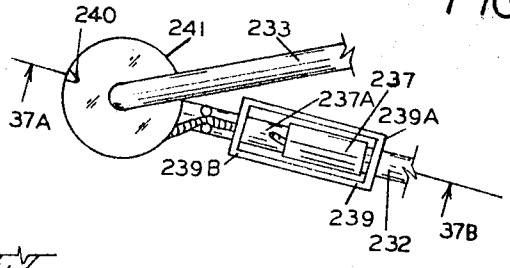
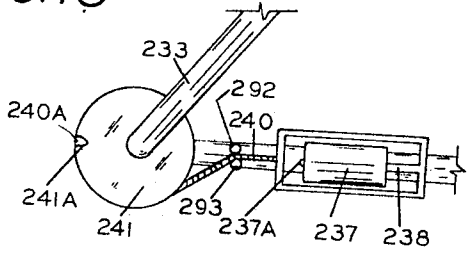


FIG. 18



F. J. SMITH JR.
AND J. L. SMITH
INVENTORS

BY

ATTORNEY

May 27, 1969 F. J. SMITH, JR., ET AL 3,446,434

IRRIGATING APPARATUS CONNECTOR ASSEMBLY

Filed April 26, 1968

Sheet 7 of 12

FIG. 19

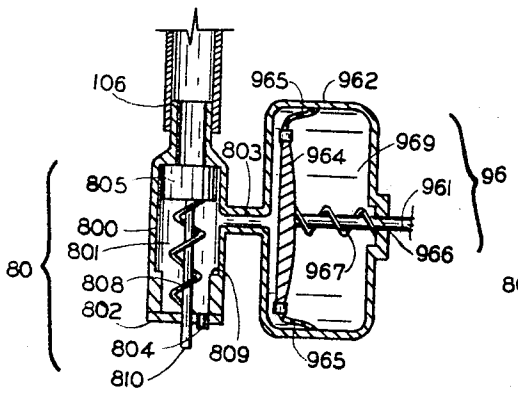
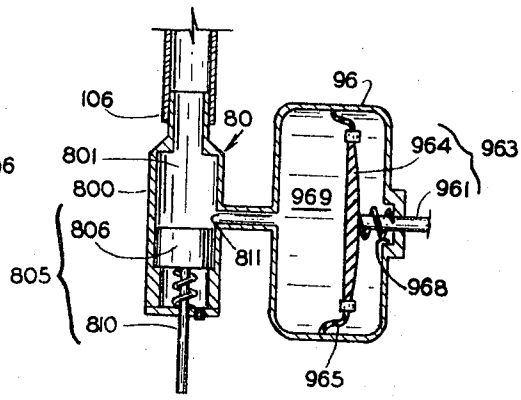


FIG. 20



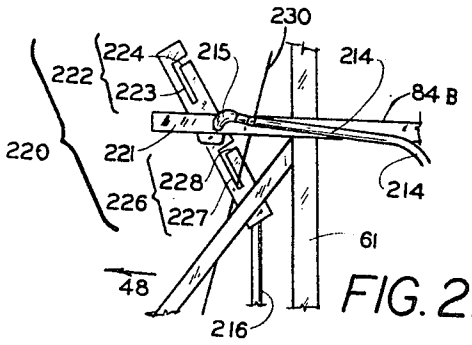


FIG. 21

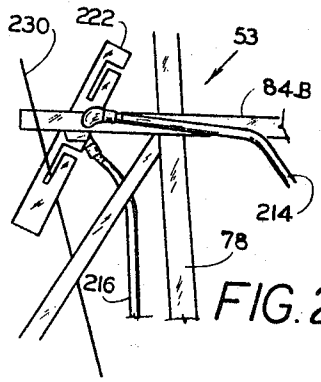


FIG. 22

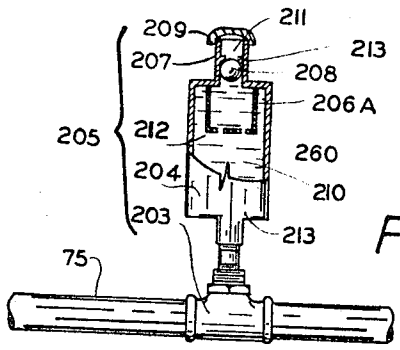


FIG. 23

INVENTORS
F. J. SMITH JR.
& J. L. SMITH

BY Ely Silverman
ATTORNEY

May 27, 1969 F. J. SMITH, JR., ET AL 3,446,434

IRRIGATING APPARATUS CONNECTOR ASSEMBLY

Filed April 26, 1968

Sheet 8 of 12

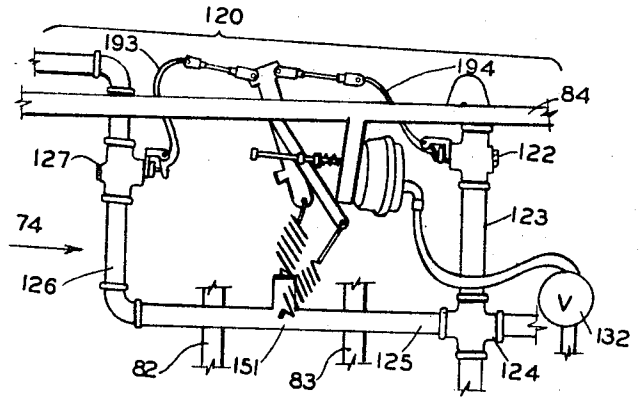


FIG. 24

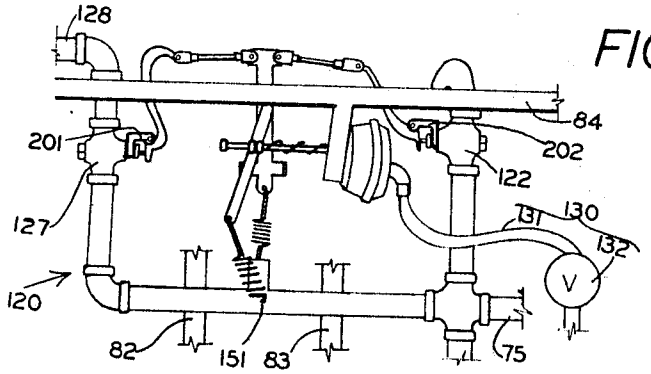


FIG. 25

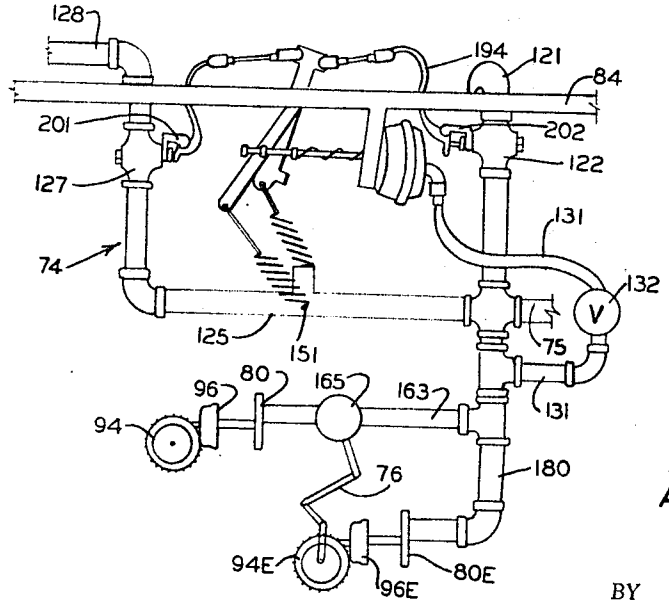


FIG. 26

F. J. SMITH JR.
AND J.L. SMITH
INVENTORS

BY

Ely Silverman
ATTORNEY

May 27, 1969 F. J. SMITH, JR., ET AL 3,446,434

IRRIGATING APPARATUS CONNECTOR ASSEMBLY

Filed April 26, 1968 Sheet 9 of 12

FIG. 27

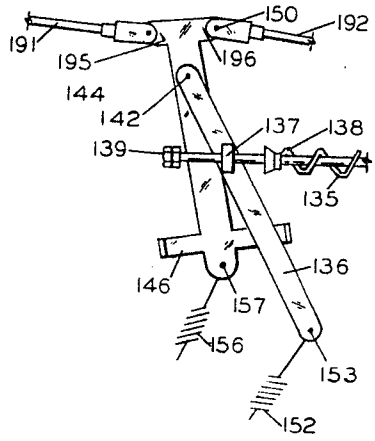


FIG. 30

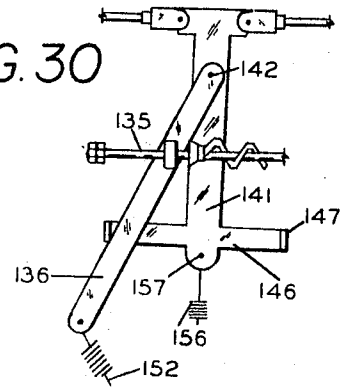


FIG. 28

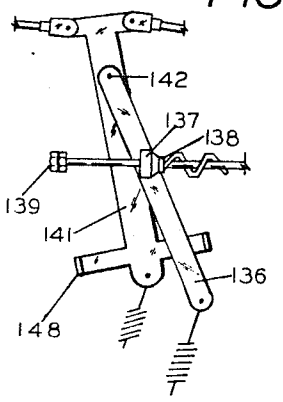


FIG. 31

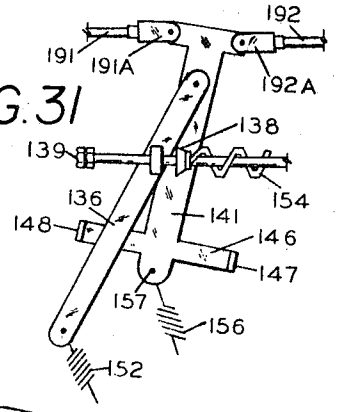


FIG. 29

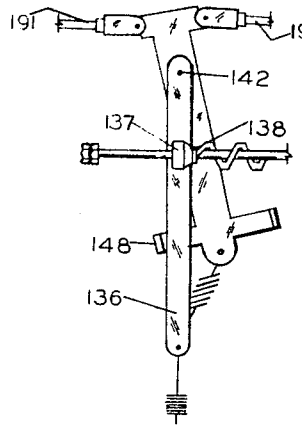
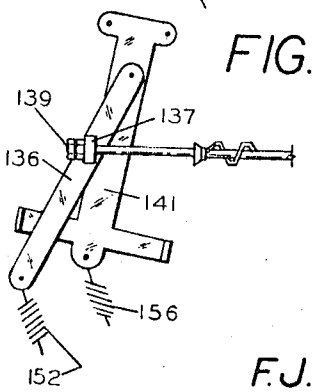


FIG. 32



F. J. SMITH JR.
AND J. L. SMITH
INVENTORS

BY

Ely Silverman
ATTORNEY

May 27, 1969 F. J. SMITH, JR., ET AL 3,446,434

IRRIGATING APPARATUS CONNECTOR ASSEMBLY

Filed April 26, 1968

Sheet 10 of 12

FIG. 33

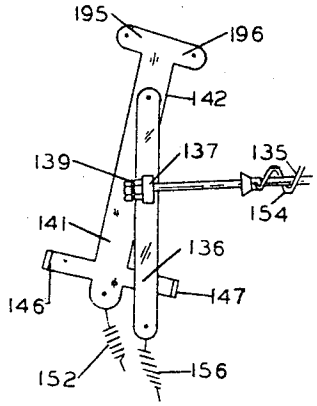


FIG. 34

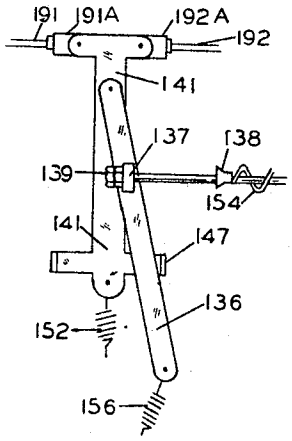


FIG. 35

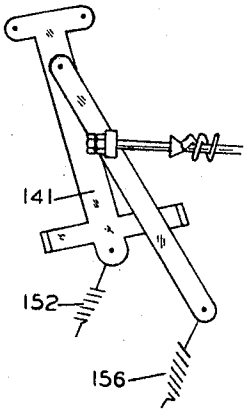


FIG. 36

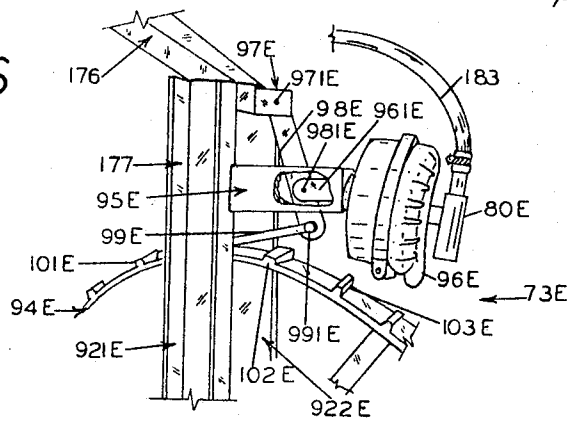
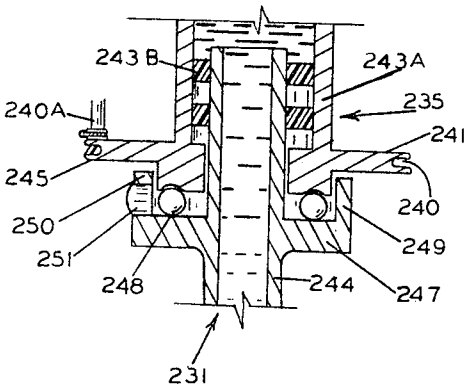


FIG. 37



F. J. SMITH JR.
AND J. L. SMITH
INVENTORS

BY

Ely Silverman
ATTORNEY

May 27, 1969 F. J. SMITH, JR., ET AL 3,446,434

IRRIGATING APPARATUS, CONNECTOR ASSEMBLY

Filed April 26, 1968 Sheet 11 of 12

FIG. 38

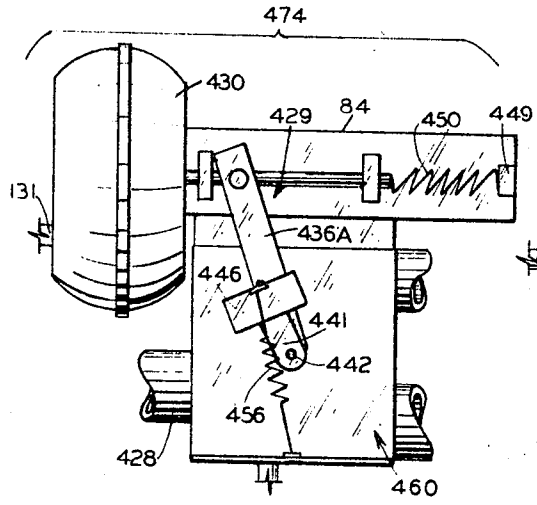


FIG. 39

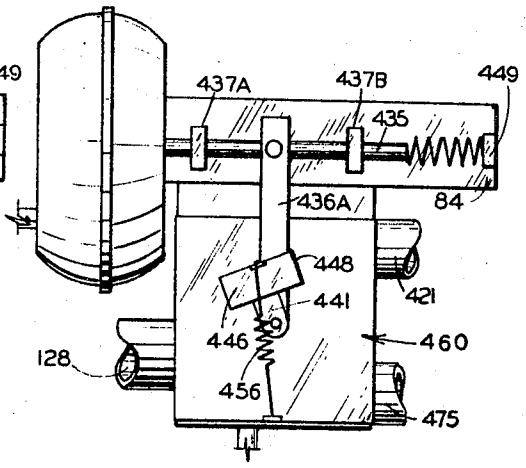
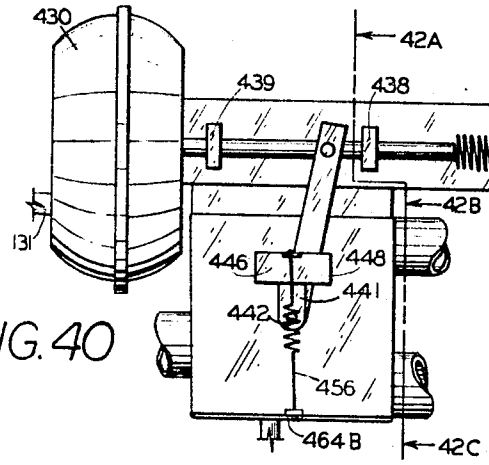


FIG. 40



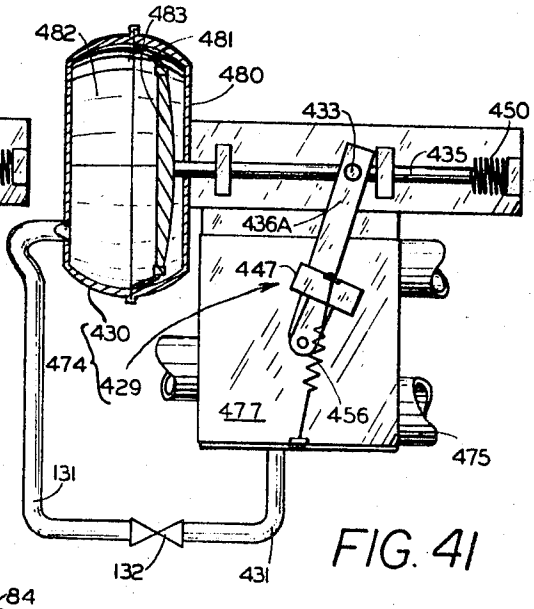


FIG. 41

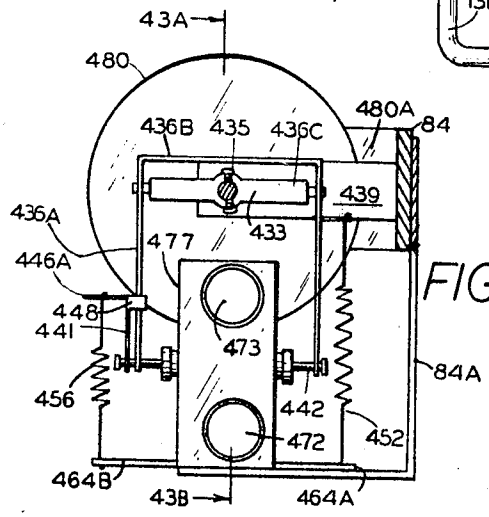


FIG. 42

F. J. SMITH JR.
AND J. L. SMITH
INVENTORS

BY

Ely Silverman
ATTORNEY

May 27, 1969 F. J. SMITH, JR., ET AL 3,446,434

IRRIGATING APPARATUS CONNECTOR ASSEMBLY

Filed April 26, 1968

Sheet 12 of 12

FIG. 43

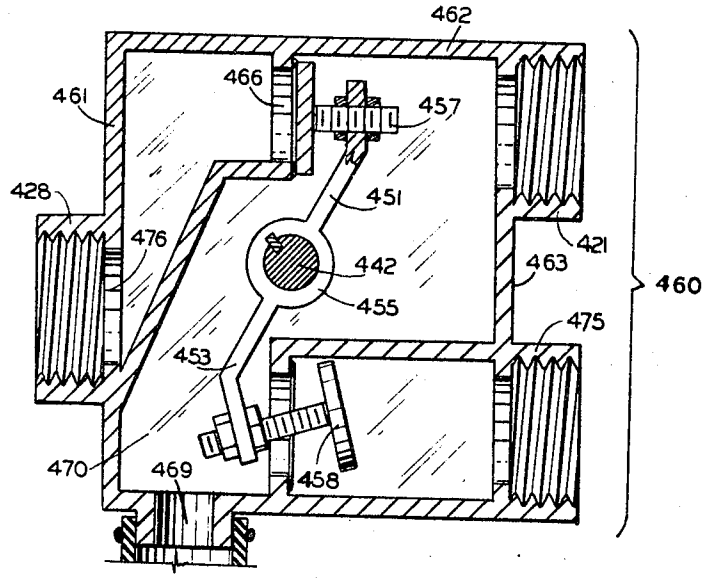
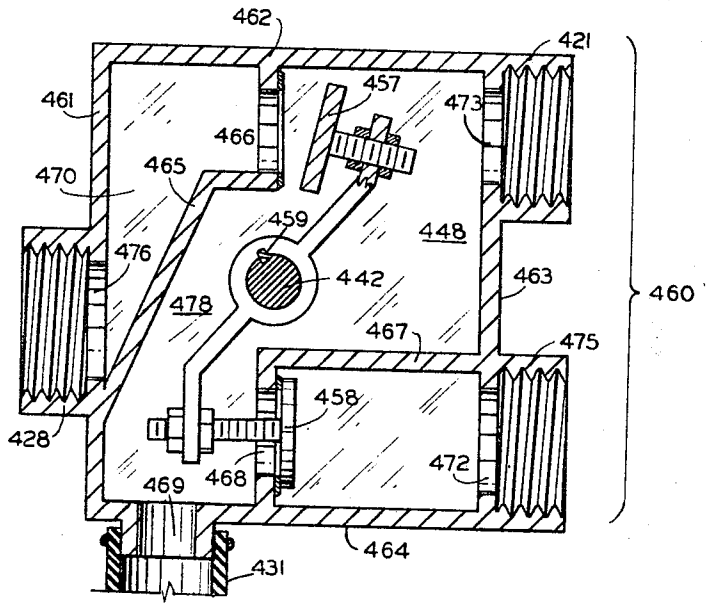


FIG. 44



INVENTORS
F.J. SMITH JR.
& J.L. SMITH

BY Ely Silverman
ATTORNEY

United States Patent Office 3,446,434
Patented May 27, 1969

3,446,434

IRRIGATING APPARATUS CONNECTOR ASSEMBLY

Frank J. Smith, Jr., Star Route, Logan, N. Mex. 88426, and Jarrell Lee Smith, San Jon, N. Mex. 88434

Continuation-in-part of application Ser. No. 565,931, July 18, 1966, now Patent No. 3,381,893. This application Apr. 26, 1968, Ser. No. 724,582
Int. Cl. B05b 15/06, 15/10; A01g 25/02
U.S. Cl. 239—212
5 Claims

ABSTRACT OF THE DISCLOSURE

A connector assembly for use between a moving sprinkler bearing pipe supported on a series of moving wheeled pipe supporting stations and a source of water therefore, comprising a series of rigid pipes operatively and pivotally connected with means therebetween for applying the pressure of said liquid to lengthen and shorten the distance between the ends of the connector assembly series of rigid pipes as the distance between the sprinkler bearing pipe and the source of water therefore increases and decreases. An improved timer for an irrigator is also provided.

Cross reference to related application

This application is a continuation-in-part of our pending application S.N. 565,931 filed July 18, 1966, to be issued on May 7, 1968, as U.S. Patent 3,381,893.

This application is directed to the connector assembly **60** shown in said application S.N. 565,931 and also provides an improved hydraulic engine time subassembly **474** for use in lieu of the assembly **74** of said pending application Serial No. 565,931.

Background of the invention

(*1*) *The field of the invention.*—This invention lies in the field of fluid handling apparatus, and a hydraulic timer.

(*2*) *Description of the prior art.*—The prior method of connecting a moving irrigation sprinkler comprising a series of pipe supporting wheeled stations supporting a sprinkler supporting pipe with the source of water therefor under pressure is usually a matter of using a flexible hose to connect the main line to one end of a traveling sprinkler pipe; present "zipper" apparatuses being not practical in the dusty climate in which irrigation apparatuses are intended to operate. Due to the pressures and pulses of pressure in such hoses which are usually coiled, and resulting tangling thereof in some instances, such hoses move substantially, causing danger to workers near such apparatus as well as causing varying pressure drops through such coil and/or tangled lines. Moreover the varied configuration of such hoses exert force varying in direction as well as in amount on the pipe supporting station nearest to which such connector lines are attached in the series of pipe supporting stations supporting the sprinkler pipe.

Summary of the invention

The connecting assembly apparatus of this invention avoids hose coiling, tangling, pressure variations and uses the pressure of the liquid traveling through such connector assembly to keep the connector assembly ends so arranged as to minimize mechanical interferences with the positioning of the pipe supporting stations of the sprinkler assembly.

The timing assembly of this invention is of improved simplicity of construction and sturdiness.

Further, the connector of this invention is not only adapted for continuous movement but it is so without

high bearing stress on land or on power transmission elements. Additionally, the apparatus and process of this invention do not require lubricants that are exposed and lost to the field for power transmission from the power source to the pipe supporting stations. The connector of this invention may also be automatically stopped and strated on stopping and starting of the flow of irrigation fluid therethrough.

One object of this invention is to provide a method for continuous operation of irrigation apparatus.

Another object of this invention is to provide an improved connector for a sprinkler apparatus adapted for movement over land and/or crops to be irrigated.

Still a further object is an improved escapement mechanism which provides for the drive of hydraulically powered irrigation apparatus over fields to be treated.

Brief description of the drawings

In the drawings FIGURES 1, 2 and 3 are diagrammatic isometric views of the overall structure of the apparatus of the invention in sequential positions of the water line connector assembly and the sprinkler assembly during operation of the apparatus.

FIGURE 1 shows two successive positions of the apparatus **50** relative to the pipeline **43** during motion thereof across a field **40** upward and to the left; FIGURE 2 shows two successive positions of the water line connector and the sprinkler assembly and the pipe line during travel to positions further upward and leftward than shown in FIGURE 1; FIGURE 3 shows two sequential positions of the water line connector assembly and the sprinkler assembly during motion thereof in a direction downward and to the right on the opposite side of the water line **43** than shown in FIGURES 1 and 2 during operation of apparatus **50**.

FIGURES 4, 5, and 6 are isometric diagrammatic views of representative portions of the overall sprinkler assembly **51** to a larger scale than in FIGURES 1–3 and showing portions of the major parts thereof during different operative positions thereof.

FIGURES 4 and 5 show the wheel subassemblies of the stations oriented in planes perpendicular to the length of the pipe **511** of the sprinkler assembly **51** for motion transverse to the direction of length of the pipe **511**. FIGURE 4 shows major subassemblies of the sprinkler assembly **51** while that assembly is moving upward and to the left as in FIGURE 1, with all stations thereof in a straight line.

FIGURE 5 shows the apparatus portions shown in FIGURE 4 in the position of the parts thereof operating as in FIGURE 4 but wherein the stations are not in a straight line, one station being in advance of and one station being to the rear of the other stations of that assembly; and FIGURE 6 is an isometric diagrammatic view of the sprinkler assembly with all the wheels of the stations thereof turned to a plane parallel to the length of the pipe **511** for motion of apparatus **51** parallel to pipe **511**.

FIGURE 7 is an isometric piping diagram, not to scale, of piston valve and piping connections in the hydraulic engine timer subassembly and pacemaker assembly at the end station **52** and in the adjacent station **53**.

FIGURE 8 is an enlarged view of the valve control link subassembly in zone **8A** of FIGURE 11 and FIGURE 7.

FIGURE 9 is a side perspective view to scale of stations **53** and **54** and adjacent parts of the sprinkler subassembly **51** in the position of parts thereof shown in FIGURE 4.

FIGURE 10 is an enlarged view generally to scale of assembly **73** and assembly **92** in zone **10A** of FIGURE 11 (link **98** as shown enlarged).

FIGURE 11 is a scale and perspective side view of the end station **52** in the end station wheel drive retard control position of the control frame subassembly **76**.

FIGURE 12 is a side perspective view to scale of the portions of the sprinkler subassembly shown in FIGURE 9 in the position of parts thereof as shown in FIGURE 5 wherein one of the stations, **54**, is out of line and in retard with respect to the other stations.

FIGURE 13 is a front view of the apparatus shown in FIGURE 10 with the yoke and wheel drive subassembly turned in the position thereof as shown in FIGURE 6.

FIGURE 14 is a view taken as in FIGURE 11 but with the control frame subassembly **76** shown in its end station wheel drive advance control position.

FIGURE 15 is an isometric overall view of the combination of connector assembly **60** and sprinkler assembly **51** according to the exemplary embodiment of this invention.

FIGURE 16 is a view similar to FIGURE 15 of another embodiment of connector assembly **67** and sprinkler assembly **51** of the invention.

FIGURE 17 is an enlarged diagrammatic plan view of apparatus adjacent pivot joint **231** of FIGURE 15 in the contracted position of the connector arm piston **237**.

FIGURE 18 is a view as in FIGURE 17 of the connector subassembly with the connector arm piston **237** in an expanded position.

FIGURE 19 is a diagrammatic longitudinal enlarged vertical cross-sectional view of the wheel cylinder **96** and its valve **80** shown in FIGURE 10 in the full exhaust position of the parts thereof;

FIGURE 20 is a longitudinal cross-sectional view as in FIGURE 19 of the wheel cylinder **96** and its valve **80** in the full charge and advanced position of the parts thereof;

FIGURE 21 is a diagrammatic perspective view of the station drive control valve, control arm and wire of station **53** when in their station retard position when that station is in the advanced position shown for station **57** in FIGURE 5 and as viewed along the direction of arrow **21A** of FIGURE 5;

FIGURE 22 is a diagrammatic perspective view of the station drive control valve control arm of the station drive control arm and wire of station **53** when in their station advance position when that station is in the retarded position shown for station **54** in FIGURES 5 and 12 and as viewed along the direction of arrow **22A** in FIGURE 5 and also as seen in FIGURE 12;

FIGURE 23 is a part side view and partly broken away and shown in section of the air relief valve **205**;

FIGURES 24, 25, and 26 are overall scale side views of the engine timer subassembly **74**. FIGURE 24 shows the subassembly **74** in the position of its parts at the beginning of its cycle with valve **122** open; FIGURE 25 shows the same subassembly at an intermediate portion in its cycle of operation; and FIGURE 26 shows the subassembly **74** at a later phase of one cycle of its operation with valve **122** closed; this figure also shows diagrammatically other connections of the subassembly **74**;

FIGURES 27–35 are enlarged views of arms **136** and **141** of the moving arms of the piston snap link assembly **129**; FIGURES 27–31 show the relative positions of arms **136** and **141** during the clockwise rotation thereof about pin **142** and motion of piston arm **135** and the lower portions of arms **141** and **136** to the left as shown in FIGURES 24–26;

FIGURES 31–35 show the relative positions of arms **136** and **141** during counterclockwise rotation thereof about pin **142** and motion of piston arm **135** to the right (right as in FIGURES 24–35);

FIGURE 27 shows the arms **136** and **141** of the piston snap link subassembly in the positions thereof shown in FIGURE 24; FIGURE 28 shows the arms **141** and **136** of the piston snap link subassembly in the position thereof subsequent to that shown in FIGURE 27 during the sequence of the motion of the bottom of the arms of the snap link subassembly leftwards in clockwise rotation as shown in FIGURES 24–26; FIGURE 29 is an enlarged view of the arms **141** and **136** of the snap subassembly in the position thereof as shown in FIGURE 25, and subsequent to that shown in FIGURE 28, during the leftward or clockwise (as shown in FIGURES 24–26) motion of the bottoms of the arms **141** and **136** of the piston snap link subassembly; FIGURE 30 is a view of arms **136** and **141** in a further leftward or clockwise rotary motion of those arms of the snap subassembly **121** in a position immediately subsequent to that shown in FIGURE 29;

FIGURE 31 is an enlarged view of the arms **136** and **141** of snap subassembly **129** in the position thereof generally as shown in FIGURE 26 of the snap subassembly; i.e., in the furthest clockwise rotated position thereof wherein the bottom portion thereof are further leftward of the position thereof shown in FIGURES 30 and 25.

FIGURE 32 shows the position of the snap subassembly arms **136** and **141** on beginning of counterclockwise rotation from the positions shown in FIGURES 26 and 32; FIGURE 33 shows the position of arms **136** and **141** on a further counterclockwise rightward motion from their position shown in FIGURE 33; FIGURE 34 shows a position of arms **136** and **141** further counterclockwise than in FIGURE 33 and on first engagement of the elements **141** and **136** in a position similar to that shown in FIGURE 29 but in the opposite direction; FIGURE 35 shows the position of arms **136** and **141** immediately subsequent to slight counterclockwise motion of arm **136** from the position thereof shown in FIGURE 34 and to that position of arms **131** and **146** shown in FIGURES 24 and 27.

FIGURE 36 is an enlarged side view, partly broken away, of zone **36A** of FIGURE 14, generally to scale.

FIGURE 37 is a diagrammatic vertical longitudinal diametral cross-section view of coupling joint **231**, generally along vertical plane **37A–37B** of FIGURE 17.

FIGURES 38, 39, 40 and 41 are side views of a hydraulic engine time subassembly **474**. FIGURE 41 being partly in section. FIGURE 38 shows the subassembly **474** in the position of its parts at the beginning of a series of clockwise motion of arm **440**; FIGURE 39 shows the same subassembly at an intermediate portion in its clockwise operation. FIGURE 40 shows the subassembly **474** at a later phase of clockwise operation with arm **440** in its "teeter" position.

FIGURE 41 shows a later stage with arm **440** snapped to the right.

FIGURE 42 is an end view along plane **42A–42B–42C** of FIGURE 40.

FIGURES 43 and 44 are enlarged vertical longitudinal cross-sectional views along section **43A**, **44A** of FIGURE 42.

Other objects of this invention will become apparent to those skilled in the art on the study of the hereto attached and below discussed drawings, which description of the drawings forms a part of this specification and in which drawings the same reference numeral refers to the same part throughout. Some of these drawings are shown to scale to facilitate understanding of the description thereof, while others are shown diagrammatically to accentuate the principle of operation thereof or to illustrate critical although physically small features thereof.

Description of the preferred embodiment

The apparatus **50** according to this invention comprises a sprinkler assembly **51** and a connector assembly **60**. The apparatus **51** is adapted to treat a field as **40** which field has a right hand portion **41** and a left hand portion **42** and through which field a straight irrigation pipeline **43** extends. A series of conventional valves, as **44** and **44A**, are each operatively attached to the line **43** at regularly spaced intervals of about 100 feet. Each valve, as **44**, serves through a disconnect coupling and a pivotal joint

235, to operatively and rotatably connect one end of the subassembly 60 to line 43. The other end of the connector subassembly 60 is operatively and rotatably connected by a movably located pivot joint 270 to the sprinkler assembly 51 and provides, as below described, for operative connection of line 43 to assembly 51 during movement of the apparatus 50 lengthwise of the field 40 in the forward direction (arrow 48) or rearward direction (arrow 49).

The line 43 is operatively connected to a conventional pump 45 which is operatively connected to a power source therefor, as a 200 H.P. engine 47 and to a well 46 which includes a source of water. Sprinkler assembly 51 comprises a main pipeline 511 and a plurality of similar movable stations 52–59 firmly attached to and supporting said pipe. Each of the intermediate stations, as 53–58, comprises a similar frame and a pair of driving wheel assemblies operatively attached thereto. Each of the end stations as 52 and 59 are also provided with a pacemaker and a timer assembly. In the embodiment 51 the end stations as 52 and 59 are spaced 30 feet from the station adjacent thereto as 53 and 58, respectively: the intermediate stations as 53, 54, 55, 56, and 57 are spaced apart 60 feet; there are 20 like intermediate stations as 53–58 and two end stations in the exemplary embodiment of assembly 51.

End station 52 comprises a frame 70 with (as shown in FIGURES 1, 4, 7, 11, and 14) a front wheel assembly 72 and a rear wheel assembly, as 73. Each of the intermediate stations, as 53, is provided with a frame as 61 similar to frame 70 and is provided with front and rear wheel assemblies, as 62 and 63, structurally and functionally identical to assemblies 72 and 73, respectively. The frame 64 (alike to 61) of assembly 54 (alike to 53) is provided with like front and rear wheel assemblies 65 and 66 like 62 and 63, respectively. The end stations 52 and 59 are identical in structure to each other and the intermediate stations 53 through 58 are identical in structure to each other. The end stations 52 and 59 are located at the lateral ends of the pipe 511 and are identical in structure. The end station 52 is located near one lateral end of the pipe 511 (left in FIGURES 1, 3, 4, 11, and 14) and includes the same structure of frame and wheel assemblies as do the intermediate stations as 53 through 59. Each end station as 52 is also provided with a hydraulic engine timer subassembly, 74, and a pacemaker or control subassembly 76. End station 59 is located at the right end of assembly 51 (right as shown in FIGURE 1). The subassemblies and the components of station 59 are given the same reference numeral as in station 52 followed by the letter "G" for corresponding subassemblies and components.

The control subassembly 76 is operatively connected to the hydraulic engine timer subassembly 74. The engine timer subassembly 74 is operatively connected to the wheel assemblies 72 and 73 of the station 52. The engine timer subassembly 74 is also operatively and separately connected by the hydraulic drive line 75 to the drive mechanism of each intermediate station, as 53. The line 75 extends along and is mechanically supported by line 511 to each drive subassembly mechanism of each of the remaining stations (as 54, 55, 56, 57, 58, and 59) on the sprinkler assembly 51. The drive mechanisms of each station are thus connected separately to line 75 and, thereby, pump 45.

Each frame as 70 comprises a rigid lower horizontal base angle iron member 81 and, firmly attached thereto near the center thereof, a pair of rigid vertical pipe supporting arms, front arm 82 and rear arm 83. These arms, made of 2-inch steel L's in the exemplary embodiment are each firmly attached to each of three horizontal transverse arms 84, 85, and 86; top transverse arm 85, intermediate transverse arm 86 and a middle transverse guide wire arm 84; arm 84 extends beyond the front and rear of the arms 82 and 83. A rigid front diagonal support member 87 and rear diagonal support member 88 are each made of 2-inch steel L's and are firmly joined at their top to the arms 82 and 83, respectively, and, at their bottoms to a front vertical pivot support arm 90 at the front and to a rear vertical pivot support arm 91 at the rear, respectively, of the base arm 81.

The drive wheel assemblies 72 and 73 are formed of identical structures and members; the structures and members of assembly 72 are indicated by the same reference numerals as corresponding structures and members on assembly 73 except that the letter "A" follows the reference numeral for the structures and members of assembly 72.

The drive wheel assembly 73 (see FIGURES 10 and 13) comprises a yoke 92, an axle 93, a cleated wheel 94, a piston 96 and a valve 80. The yoke 92 has left and right side arms 922 and 921 (as seen in FIGURE 13); these arms firmly attach to and support the axle 93. The axle rotatably supports the wheel 94 (also, the axle and arms can be regarded as rotatably supported by the wheel). The arms of a rigid U-shaped bracket 95 are firmly attached to the arms 921 and 922 of the yoke 92 and extend horizontally. A hydraulic piston 96 is supported firmly on the outer base, end of the bracket 95. A rigid piston arm 961 is connected to and extends from the piston towards the space between arms 921 and 922 of the yoke 95. A rigid U-shaped lug 97 is firmly attached to the top of the yoke 92 above bracket 95. A rigid lever arm 98 is pivotally attached by a pin 971 between the arms of lug 97. The forward end of arm 961 is pivotally attached to the arm 98 below pin 971 by a pin 981. A rigid drive link 99 is pivotally connected at its rear end by a pin 991 to the lower end of the arm 98 and rests on the top of the rim of wheel 94 at its front end.

The rim of the drive wheel 94 is, at its entire radial periphery, provided with a series of radially extending equispaced ground engaging cleats as 101, 102, and 103. The link 99 in its operation successively engages and moves each of those cleats one at a time. A rigid locking link 105 is pivotally connected to the yoke arm 922 to provide one-way motion of the wheel 94; in conventional manner it firmly engages the cleats, as 101, one at a time following their propulsion by link 99. Firmly attached thereto, the yoke 92 has at its upper end a vertical cylindrical pivot shaft 921 that is pivotally and firmly located in a cylindrical cavity therefor in the arm 91. A U-shaped bracket 923 is firmly attached to arm 91. A pin 922 is held to arm 91 by bracket 923 and is spring urged toward shaft 921. Shaft 921 has radial holes at its surface that engage pin 922 to hold the arms of yoke 92 in a plane parallel to pipe 511 as in FIGURE 10, or in a plane transverse thereto as in FIGURE 13.

The same drive wheel structures as in subassembly 73 are provided in the drive wheel subassemblies of all the stations of assembly 51; the corresponding elements thereof are denominated by the same reference numeral and the letter "B" for the elements in wheel subassembly 62 and "C" for the corresponding subassemblies in the wheel subassembly 63. Guy wires from each frame assembly of each station as 52, 53, 54, and 55 are firmly attached to the adjacent pipe 511 about a third of the distance between stations from the arms as 85 on station 52 and from the ends of arms as 84 on station 52; for instance, the wires 110 and 111 extend from the frame 54 to the pipe 511 to the left (as shown in FIGURE 12) and corresponding wires 112 and 113 correspondingly extend to the right side of the station 54; additional front and rear guy wires as 116 and 117 are provided to attach and guy each frame station relative to the adjacent portion of the pipe 511. Additionally, guy wires 114 and 115 extend between the tops of adjacent stations as 52 and 53 and 53 and 54 to help align those stations relative to each other.

The piston subassembly 96 comprises (see FIGURES 19 and 20) a cylindrical casing 962 within which is a cylinder chamber 969 and wherein is located a movable

piston **963**. The piston **963** comprises a rigid flat piston plate **964** and the rigid piston arm **961** attached thereto. A flexible water-tight piston seal **965** attaches the plate **964** to the interior of the casing **962** in a water-tight fashion. The piston arm **961** is a sturdy shaft of uniform transverse cross-section located in a cylindrical bore **966** of the housing **962** which permits axal motion of the piston arm **961** in a direction perpendicular to the length of the plate **964**. A compression spring **967** provides for urging the plate **964** away from bore **966**.

Each wheel piston valve subassembly as **80** (see FIGURE 19) comprises a vertical hollow cylindrical shell **800**, a vertical longitudinal chamber **801** therein, and, in said chamber, a longitudinally reciprocatable piston **805**.

The shell **801** has a lower end wall **802** which has an orifice **804** therein for movement of a manual adjustment arm **810** portion of the piston therethrough and a side connection **803** to the piston **96**. The piston **805** comprises a piston head **806** and a piston arm **810** and a compression spring **808**. The piston head **806** forms a watertight yet slidable fit with the walls of chamber **801**. Rod **810** is fixed to the head **806**. Spring **808** fits around rod **810**. The interior face of the end wall **802** forms a seat on which the bottom of the spring **808** seats.

A shoulder **809**, higher than the compressed spring **808**, with the distance from shoulder **809** to bottom of the orifice **811** (from chamber **801** to **969**) greater than the height of head **806** is located in chamber **801**. It supports head **806** on charging of piston **96** by fluid from line **106** as shown in FIGURE 20. On release of pressure in line **106**, the top of the spring **808**, which spring is a compression spring, based on end wall **802**, forces the piston head **806** upward past the point of the orifice **811** between the chamber **801** and the passage **803** therefrom to the piston chamber **969** and in that expanded position of the spring **808** the head **806** seals the line **106** from orifice **811** and the remainder of the chamber **801**, as shown in FIGURE 19. Sufficient pressure (40 lbs. p.s.i.g. in embodiment **50**) in line **106** overcomes the force of the spring **808** and moves head **806** below orifice **811** and provides, through the orifice **811** and the connection **803**, a continuous passage to the chamber **969** within piston **96**.

As shown in FIGURES 19 and 20 on application of liquid pressure through the line **106** the movable piston **806** of the valve **80** is forced down and the pressure of the fluid (40–100 lbs. p.s.i.g.) is applied against the plate **964** and that plate and piston **961** moves to the right (right as shown in FIGURES 19 and 20).

At the same time that the piston **964** moves the arm **961** outward of casing **962** from its released position shown in FIGURE 19 to its forward position shown in FIGURE 20, it moves the link arm **99** to the left as shown in FIGURE 10 and provides thereby for motion of the wheel **94** a step in the counterclockwise direction (for the arrangement shown in FIGURE 10). On release of the pressure in the line **106** the plate **964**, under the urging of the compression spring **967** (which is seated at one end against the portion of the seat **968** therefor in the casing **962**) urges the piston plate **964** leftward as shown in FIGURE 19: at the same time the spring **808** and head **806** in the valve **80** moves upward from the position shown in FIGURE 20 to the position shown in FIGURE 19. This provides for the escape of the water from the chamber **969** of the casing **962** to be discharged outward through the orifice **804** of valve **80**.

The hydraulic engine timer subassembly **74** is firmly supported on arms **82**, **83**, and **84** of the frame **70** of the end station **52**. The engine timer subassembly **74** comprises a valve support subassembly **120** and a piston and link and spring subassembly **129** (FIGURE 26) operatively connected. The timer assembly **74** cooperates with but is not a part of the pacemaker control subassembly **76**.

Subassembly **74** is directed to providing a repeated periodic hydraulic pulse for all the drive wheels of all the stations of assembly **51**. Subassembly **74G** of station **59** (similar to **74** of station **52**) also provides a periodic pressure pulse for driving all the drive wheels of all of the stations of assembly **51**. The utilization of the pulse to move each station by the drive wheel mechanism of that station depends, in the exemplary embodiment, on the position of that station relative to the other stations of assembly **51** and is controlled by the wire **230** and control arms, as **220** on station **53** for that station.

Subassembly **76** is directed to control the linear speed of station **52** (a similar subassembly **59G** controls the speed of the other end station **59**); the interstation control assembly keeps the intermediate stations as **53–58** of assembly **51** in a straight line between end stations as **52** and **59**.

The valve support assembly **120** comprises an input hose line **121** which extends from and operatively connects the line **511** to the top of normally open input valve **122**. Valve **122** is operatively connected (through arms **192** and **194**) to and controlled by a snap link arm **141** of the piston link subassembly **129**. The bottom of valve **122** is firmly and operatively connected to the top of a vertical rigid conduit line **123** (2″ I.D. pipe in the exemplary embodiment). The bottom of line **123** is firmly connected to a cross **124**. One horizontal arm of the cross is firmly connected to the right (as seen in FIGURE 24) end of a horizontal rigid conduit line **125**. Line **125** is a rigid pipe (2″ I.D.) and firmly connected to and supported by arms **82** and **83** near to its center: at its left end (as shown in FIGURES 24–26) line **125** is connected to a rigid vretical arm **126** parallel to line **123**. The top of line **126** is operatively connected to the bottom of normally closed exhaust valve **127**. Valve **127** is operatively connected by its rigid linkage arms **191** and **193** to the top of the snap link **141** of the piston and link subassembly **129**. Valve **122** is connected by its rigid link arms to the top of arm **141**. By this common connection to the snap link arm **141** the valves **122** and **127** are, at any one time during operation of apparatus **51** one open and the other closed and, at another time the other open and the one closed. The upper end of the valve **127** is operatively connected to a discharge conduit line **128**. The line **128** is operatively connected to a discharge pipe **158**. The upper ends of valves **122** and **127** are firmly fixed to and supported by arm **84** of frame **70**.

The piston link and spring subassembly **129** comprises a piston chamber assembly **130** and a piston snap link and spring assembly **140** (FIGURE 26). Assembly **130** comprises a piston chamber **134** which is in operative hydraulic series connection with a piston chamber line **131**, which is in series connection with the piston chamber line control valve **132** which is operatively connected with the cross **124**. The piston chamber **134** is firmly mechanically connected and supported by a rigid vertical support arm **133** attached at its top to the bottom of arm **84** about ⅓ distance from valve **122** to valve **127**.

The piston chamber **134** is identical in structure to the piston **96** and is provided with a similar piston shaft (**135**) which is moved out of the chamber of piston **134** by the action of the fluid in the line **131**. A supplemental tension spring **154** (supplemental to a spring as **967**) moves the piston into the chamber.

The snap link and spring subassembly **140** comprises a piston link **136** and its spring and a snap link assembly **140** operatively connected as below described.

The top end of a rigid piston link **136** is pivotally supported on a pin **142** firmly attached to the middle of member **84**. The piston link **136** is provided with a slide **137** within which the piston **135** of the piston chamber **130** slidably fits. The piston shaft **135** is provided with a pair of right-hand adjustment lock nuts **138** and a pair of lef-hand adjustment lock nuts **139** firmly fixed thereto

near to its left (as shown in FIGURES 24–35) and right ends, respectively, to control the motion of arm **136** and, thereby, arm **141** and valves **122** and **127**.

The bottom end of link **136** is attached by a compression spring **152** to a bracket **151** on the front (as shown in FIGURES 24–26) arm **125** below the location of pin **142** in arm **84**. Spring **152** fits in hole **153** at bottom of arm **136**.

The snap link assembly **140** comprises, in operative pivoted connection, a rigid snap link arm **141**, upper rigid exhaust valve arms **191** and **193**, upper rigid inlet valve arms **192** and **194** and a spring **156**.

Arm **141** is vertically elongated and shaped generally like the capital letter I (as in I-beam). Left and right ears **195** and **196** project laterally from the upper end of arm **141**. Ear **195** supports pin **191A**; ear **196** supports pin **192A**; pin **191A** pivotally supports arm **191**; pin **192A** pivotally supports arm **192**. At its lower end arm **141** has a laterally and forwardly projecting U-shaped arm **146**; arm **146** is provided at its right end with a forwardly projecting right ear **147** and at its left end with a forwardly projecting left ear **148** (right and left as shown in FIGURES 24–35). These ears extend perpendicular to the length of the piston shaft **135** and are parallel to the length of the pipe **511**.

The arm **125** firmly supports at its front (as shown in FIGURES 24–35) a piston spring bracket **151** and at its rear firmly supports a snap link bracket **155**. A piston spring **152** is attached to and compressed between the bracket **151** and the lower end of the arm **136** at hole **153**. A snap link spring **156** is operatively connected at its top to the bottom of the snap link arm **141** in a hole **157** therefor and its lower end is firmly attached to the bracket **155**. These springs are compressed in their vertical position more than when in a diagonal position.

A rigid valve arm **191** is pivotally connected by a pin **197** to rigid valve arm **193** which is pivoted about a pin **199** which pin is firmly supported in the arm **84** near valve **127**: arm **193** is pivotally connected to a valve lever support arm **201** which operates on a piston to move the normally closed valve **127** to its open position and to close it. A rigid valve arm **192** is pivotally connected by a pin **198** to a rigid valve arm **194** which is pivoted about a pin **200** which pin is firmly supported in the arm **84** near valve **122**; arm **194** is pivotally connected to a valve lever support arm **202** which operates on a valve piston to move the normally open valve **122** to the closed position and to open it.

Arm **141** and arm **136** are both pivotally supported on pin **142** which pin is firmly supported in arm **84** near its middle, halfway between valves **122** and **127**. Arm **136** is located between ears **147** and **148** of arm **146** of link arm **141** and is engageable by the ear **147** or **148**. Slide **137** of arm **136** is located above arm **146**; arm **136** extends below arm **146** to spring hole **153**.

The pacemaker control frame subassembly **76** comprises a rigid forward lead arm **170** and a rear driven arm **176** pivotally connected together. Assembly **76** is pivotally connected by pin **971** to lug **97** on the yoke **92** of end station **52**. A similar frame assembly **76G** is attached to the frame of the other end station **59**. The pivotal connection between arm **176** and pin **971** of yoke **92** permits rotation of arm **170** only in a vertical plane parallel to the vertical plane of wheel **94**. The pivotal connection of arm **170** to arm **176** at a rigid pivot pin **179** (FIGURE 8) near the top of arm **176** permits relative rotation therebetween only in the same vertical plane. Assembly **76** includes a yoke **177** and a wheel assembly **73E**. Arm **170** has a rigid left portion **171** and a rigid right portion **172** (as shown in FIGURE 8) rigidly joined to and by rigid braces as **170A** and **170B**. The arms **171** and **172** are connected by a rigid pivot pin **971** to the lug **97** on the yoke **92**.

The pin **971** is threaded at its ends and provided with removable nuts for ready removal of assembly **76** from or attachment to lug **97** on yoke **92** on assembly **73** or lug **97A** on yoke **92A** of assembly **72**.

The driven arm **176** comprises a rigid left arm, **176B** and rigid right arm **176A** (as seen in FIGURE 8) firmly joined at their front end by a rigid brace **175A** and a rigid brace **175B** at their rear. A pair of yoke arms **921E** and **922E** form a downwardly extending yoke **177** which is firmly and rigidly attached to arm **176**; a wheel **94E** is rotatably supported on an axle on yoke **93E** (FIGURE 36). Wheel **94E** is the same diameter as wheels **94A** and **94** but the cleats, as **101E**, **102E** on wheel **94E** are spaced apart only 4/5 of the distance that the cleats as **101**, **102**, and **103** of wheels **94** and **94A** (and **94B** and **94C**) are spaced apart along the rim of such wheels.

A piston **96E** for wheel **94E** is firmly supported by an ear **95E**. Ear **95E** is firmly attached onto the arms of the yoke **177**. A valve **80E** corresponds in structure and function to the valve **80** and is operatively attached to the piston **96E**.

All components of the subassembly **73E** on the pacemaker wheel subassembly **76**, are given the reference letter "E" and numbers corresponding to the corresponding part in assembly **73**, and have the same structure and size as in assembly **73** except for the connection of links corresponding to those (**98** and **961**) connected to pin **981**. In assembly **73E** the piston **96E** is connected to the link **98E** (corresponding to link **98** for wheel assembly **73**) to provide link **99E** and wheel **94E** only 4/5 of the linear motion of the link **99** per stroke of piston **96E**. The rigid piston shaft **961E** of piston **96E** is pivotally attached by a rigid pin **981E** to a rigid link **98E**: link **98E** is pivotally attached to an upper fixed pivot pin **971E** at lug **97E** and, at a lower pin **991E**, link **98E** pivotally attaches to drive link **99E**. Link **99E** is rigid and contacts and drives wheel **94E** in the same qualitative manner as link **94** drives wheel **94** by successive tangential propulsion of its cleats.

The distance of travel of pin **961E** and **961** is the same (2½ inches): the length of links **98** and **98E** are the same (from center of pivot **971E** to **991E** and from **971** to **991**; i.e., 7 inches in preferred embodiment). However, by making the distance between centers of pins **971** and **981** three and one-half inches (3½") and distance between centers of pins **971E** and **981E** four and three-eighths (4⅜") inches, pin **991E** travels only 4/5 the distance that pin **991** travels on the same stroke of the same sized pistons **96E** and **96**.

These absolute valves of the dimension of pin travel and spacing in links **98** and **98E** are exemplary only. The feature that is important is the ratio of distance between centers of pins **971E** and **981E** and between centers of pins **981E** and **991E** relative to the distance between centers of pins **971** and **981** and between centers of pins **981** and **991** whereby even with the same drive piston travel the pacemaker wheel **94E** moves a substantially lesser amount (20% less) than the linear travel of the wheel **94** on each piston stroke.

A lug **187** is rigidly attached to the forward end of the member **175A** and is pivotally attached to a rigid link **188**. This rigid link is pivotally attached to a rigid valve arms **189**. The valve arm **189** is operatively attached to an all open or all closed valve **165** for the operation thereof. Valve **165** is firmly attached to and supported by brace **170A** of arm **171**.

The control frame assembly **76** is operatively connected with the timer subassembly **74** to control the passage of water from line **511** and valve **122** to the wheel subassemblies **72** and **73**. One arm of the timer subassembly cross **124** is operatively attached by a T **161** upper arm to the adjustable timer control valve **132**; the valve **132** is operatively connected by conduit line **131** to the piston **134**. The other, lower, end of the T **161** is firmly attached to the top end of a T **162**.

The side arm of the T **162** is operatively connected by a flexible power line hose **163** through a dimension compensating loop **164** to control valve **165** which is

supported on the arm 170 of the subassembly 76. A valved line 166 extends from the outlet of valve 165 downward of arm 170 to a T 167 which is connected to the conduit lines 106 and 106A; line 106 goes to valve 80 and powers piston 96; line 106A is operatively connected to valve 80A and is operatively connected to and drives piston 96A for wheel assembly 72 (diagrammatically shown in FIGURE 7).

The lower arm of the T 162 is hydraulically connected by a pacemaker control flexible drive line hose 180 through a flexible dimension compensating loop 181 to an up-running conduit line 182 which is mechanically supported on the arm 170 and is hydraulically continuous with and flexibly connected to a downcoming conduit line 183. Line 183 is operatively connected to the valve 80E. Valve 80E is (see FIGURE 36) operatively connected to the piston 96E; piston 96E is provided with a drive link, 961E, which drives a cleat as 101E on the wheel 94E in the same qualitative manner that the links on wheel assemblies 72 and 73 move the wheels thereof.

Accordingly, when the disposition of valves 122 and 127 (as determined by timer assembly 74) provides for passage of fluid from line 511 to T 124, water at the pressure of line 511 passes from line 511 through the hoses or lines as 181, 182, 183, valve 80E and piston 96E and serves to drive the wheel 94E. On advance of the wheel 94E toward wheel 94 and rise in height of pin 179 due to the forward motion of the driven arm 176 relative to yoke 92 the link arm 188 (FIGURE 8) causes the valve 165 to open. Accordingly, if the wheel subassembly 73 is close to wheel 94E and/or not moving as fast as the pacemaker wheel 94E; e.g., because of slippage, it and assembly 73 will be actuated and moved when the valves 165 and 122 are open by the flow of hydraulic power to the wheel piston thereof.

The wheel 94E is usually moved more slowly than (e.g., only 80% of the linear speed of) the wheels 94 and 94A. Accordingly, on operation of assembly 74 the wheels 94 and 94A only move as far as permitted by the travel wheel 94E and assembly 76. When wheel 94E is too far behind wheel 94 the movement of assembly 76 and link 188 keep the normally closed valve 165 closed. On the next cycle of the timing mechanism 74 the valve 165 is kept shut until the distance of the wheel 94E from the wheel 73 is that for which it is adjusted. Thereafter, on the next stroke of piston 134, as wheel 94E is closer to wheel 94 the valve 165 will be opened. On the overall therefore, four out of five times as an average, on each opening and closing cycle of valve 122 by the subassembly 129 (usually a cycle of about 60 seconds) the frame 70 moves a fixed distance (about 5 inches). As the stations 59 and the station 52 are identical in structure and operation, adjustment on station 59 of the valve corresponding to 165 on station 52 provides that station 59 moves at the same speed as station 52.

At each cycle of piston 134 of assembly 74 line 511 is connected hydraulically (by line 121, valve 122, line 123 and cross 124) to the main hydraulic drive line 75. Line 75 is connected separately, through the control valve (e.g., valve 215 at station 53) of the control assembly (e.g., assembly 225 of station 53) to the wheel drive pistons (e.g., 96B and 96C of station 53) of each intermediate station and thereby actuates the ground engaging wheels of that station and moves that station.

The interstation control system 225 of apparatus 51 comprises a control wire line 230, a series of control arms at each intermediate station (as 220 at station 53) connected to the wire 230, and a valve operatively connected to hydraulically powered wheels of the station and to a hydraulic power source and to the control arm, as valve 215 at station 53 is connected to line 511 and wheel assemblies 62 and 63. System 225 provides that the stations as 53–59 move at the same average speed as does the station 52.

An air relief valve 205 is provided on line 75 at each intermediate station at its bottom.

Valve 205 comprises an imperforate hollow vertical right cylindrical casing 204, the bottom 213 of which is operatively connected by a T 203 to line 75: its top is provided with a narrow vertical upstanding right cylindrical hollow neck 207. A perforated cap 209 is firmly seated on top of neck 207. A cylindrical chamber 212 is located in casing 204 and communicates via T 203 with the interior of line 75. The top of the wall 204 supports interior cylindrical perforated vertically elongated hollow cylindrical basket 206, the side and bottom walls of which basket are perforated by large perforations as 206A.

A spherical bouyant imperforate ball 208 with a diameter larger than the perforations but smaller than the diameter of the basket fits loosely in the basket: Ball 208 floats in water. The basket 205 is open at its top to cylindrical neck 207 of the casing 204. Neck 207 is of less internal diameter than the external diameter of ball 208. A cap 209 fits on neck 207: cap 209 has perforations thereon. Valve 205 provides for release of air from line 75. The air 211 that gathers above fluid 210 in chamber 212 escapes past ball 208: the ball 208, being bouyant serves as a seal against a seat 213 in neck 207 against escape of water through neck 207 after air has escaped through neck 207 and cap 209.

At each intermediate station, as 53, the line 75 is supported on the station frame, as 78, and operatively connected by a T and a power hose or line as 214 to the inlet of an intermediate station wheel drive control valve as 215. Each valve as 215 is firmly supported on frame 78 of station 53 and is an on-off valve operatively connected to and controlled by a rigid slotted wire-holding control arm, as 220. The outlet of each valve as 215 is operatively connected to a power return line 216 which line is firmly supported on the station frame as 78. Each line as 216 is hydraulically operatively connected by a T to a wheel power line as 217 which is supported on a frame member corresponding to member 81 of frame 70. At its front end line 217 is operatively connected to a valve 80B, drive cylinder 96B and wheel 94B corresponding in structure size and functions to valve 80, cylinder 96A and wheel 94A; at its rear end line 217 is operatively connected to a valve 80C, drive cylinder 96C and wheel 94C, corresponding in structure size and function to valve 80, cylinder 96 and wheel 94, respectively.

Each intermediate station frame, as frame 78 on station 53, firmly supports a rigid horizontal arm, as 84B. An on-off valve 215 identical in structure to valve 165 (FIGURE 8) is firmly attached to the arm and is connected via lines 214 and 216 to the hydraulic drive line 75 and drive wheel assemblies, as 62 and 63, of that intermediate station. A rigid control arm 220 is firmly attached to the valve arm (corresponding to arm 189 of valve 165, FIGURE 8) for pivotal motion in a vertical plane parallel to the length of arm 84B to open and close valve 165. Arm 220 is a rigid flat metal bar 1½" x ⅛" x 12" in the exemplary embodiment. It has an upper L-shaped slot 222 and a lower L-shaped slot 226. Slit 222 has a long (4" in the exemplary embodiment) central vertical portion 223 and an upper short (¾" in exemplary embodiment) horizontal entry portion 224 and is ⅛" wide throughout. Slot 226 has a long central vertical portion 227 and an upper short horizontal portion 228 all ⅛" wide. The bottoms of slots 222 and 226 are equidistant (5" in the exemplary embodiment) from the center of the arm 220 (i.e., the point on arm 220 halfway between its ends) and which center is at the level of the center of valve 215 and at the level of a horizontal projection of the length of the arm 84B. Valve 215, like 165 is a cock valve.

A sturdy control wire 230 which runs the length of the apparatus 50, from element 84 of frame 70 of station

52 to a corresponding frame element of station 59, is reliably yet removably located in slot 226 (as shown in FIGURES 21 and 22) or in slot 222 (as shown in FIGURE 7) depending on the direction of travel desired of apparatus 50. Forward and rearward (as shown in FIGURES 5, 21 and 22) of wire 230 relative to the frame of each intermediate station causes the arm 220 to rotate and to respectively open or close the valve 215 on forward motion, as shown by arrow 48, of assembly 51. The vertical slots compensate for ground irregularity between stations.

Subassembly 60 comprises a first conduit pipe 232 and a second conduit pipe 233. Pipes 233 and 232 are pivotally joined together at a pivot joint 231, joint 231 having a vertical axis whereby pipes 232 and 233 pivot in horizontal planes about the vertical axis of joint 231. Pipe 233 is pivotally yet hydraulically operatively connected to assembly 51 at pivotal joint 270; pipe 232 is pivotally yet operatively connected to valve 44 of line 43 at pivotal joint 235.

Pipe 232 is pivotally connected by a pivotable pipe coupling 235 to the valve 44 on line 43. Coupling 235 comprises a disconnect coupling 267, a fixed L 265 (with an upstanding vertical arm) fixedly connected to the coupling 267 and, connected to L 265, a pivoting L 232A. Below its vertical arm the fixed L 265 is supported on a ground support 266; the horizontal arm of L 265 is connected by a conventional disconnect coupling 267 to outlet of valve 44 on line 43.

The end of pipe 232 distant from pivot 231 has a vertical downcoming arm that forms an L 232A. This forms a pivotal and water-tight connection with the upstanding vertical arm of L 265.

Pipe 232 pivots in a horizontal plane about the common vertical longitudinal axis of the vertical arms of L 265 and L 232A, which axis is also the center of coupling 235. A wheeled support 234 is provided at about ⅔ of the distance from the vertical axis of coupling 235 to the vertical axis of joint 231.

The support 234 comprises a rigid horizontal frame 280 joined at its middle by a clamp 287 to the pipe 232. At the front of frame 280 a front pivot 283 supports a rearwardly and downwardly directed front yoke 281; the yoke rotatably supports a front wheel 282. A similarly downwardly and rearwardly directed rear yoke 284 rotatably supports at its bottom a rear wheel 285 and is pivotally attached at its front to a pivot 286 on the rear end of frame 280.

A piston chamber 237 is firmly attached to and supported on pipe 32 near joint 231. Piston chamber 237 is a horizontally elongated cylindrical chamber with its longitudinal axis parallel to and vertically above the longitudinal axis of line 232. A movable piston and a part of its rigid cylindrical shaft 238 are located within the chamber 237. One portion of the shaft 238 projects from the chamber 237. Shaft 238 is co-axial with chamber 237. A pair of cable guide roll supports 290 and 291 are firmly supported on line 232 on each side of a line, in line with the longitudinal axis of shaft 238. Front and rear grooved cable guide wheels 292 and 293 are, respectively, supported rotatably on supports 290 and 291. One end, 239A of the hollow rigid rectangular frame 239 is firmly supported on the end of the piston shaft 238 which projects from chamber 237. The other end, 239B of the frame 239 is attached by a flexible cable 240 to notch 241A in sheave plate 241 on joint 231 and is thereby held to groove 245 of plate 241.

Cable 240 contacts the grooves of wheels 290 or 291 enroute therebetween to sheave 241 and keeps frame 239 aligned with pipe 232.

Pivot joint 231 comprises an upwardly directed L, 242 (which is firmly attached to the end of pipe 232 distant from joint 235), a downwardly directed L 243 on pipe 233, a sheave plate 241, and a horizontally rotatable bearing 248.

Plate 241 is a flat horizontal annular plate: it has an internal diameter greater than the external diameter of the upstanding arm of the L 242. It has an external diameter substantially greater than the external diameter of L 243. The outer edge of plate 241 is provided wtih a groove 245. Cable 240 fits into that groove. A knot 240A or other enlargement at the end of cable 240 fits into a peripherally open radial notch 241A in plate 241. This notch permits the cable 240 to be wound clockwise as in FIGURES 16, 17, and 18 in groove 245 to notch 241A or to be wound counterclockwise about groove 245 to notch 241A as in FIGURE 15. FIGURE 15 shows the arrangement for counterclockwise rotation of arm 233 relative to arm 232, as in motion shown at FIGURE 1, when the assembly 60 contracts on motion along direction of arrow 48.

The vertically upstanding arm 244 of the lower L 242 is provided with a collar 247 which provides the base of a bearing raceway for a plurality of conventional bearing balls, as 248. The plate 241 rests on top of those balls of the raceway therefor. An annular ring 249 extends around the collar 247. The ring is provided with an orifice 250 with a plug therein, 251, through which the balls, as 248, of the bearing may be supplied thereinto. The annular plate 241 is concentric with and firmly attached to the right cylindrical vertical downcoming arm 243A of the L 243 which is firmly attached to the end of pipe 233. Conventional seals, as 243B, provide for a water-tight connection between the vertical cylindrical and co-axial arms 244 and 243A. The arm 244 provides for vertical orientation and support of the arm 243A.

The arm 233 is provided at its end adjacent to the station 52 with a downcoming L 268. The vertical portion of L 268 is pivotally joined to an upcoming L arm 269, which is attached to the pipe 511. These two vertical portions of the L are pivotally and firmly fastened together by a conventional water-tight pivotal joint structure 270 and a quick disconnect coupling 269A substantially the same as at 235.

The arm 243A vertically extends about 3 feet upwards of the plate 241. A downwardly extending rigid vertical truss compression post arm 257 is provided at and is firmly attached to the middle of arm 233. It is the same vertical length as arm 243A. Conventional truss wires, as 258 and 258A, are each attached to collars, as 259 and 260, near to the ends of the pipe 233 and to the bottom of post arm 257 and provide for a support of the pipe 233 at a height so that the pipe 233 may pass over the pipe 232 during the normal travel thereof from the positions thereof shown in FIGURE 1 to the positions shown in FIGURE 2.

The pivot connection of the pipe 233 to the pipe 511 is shown in FIGURES 16 and 7, wherein the pivoting pipe 233 is higher than the pipe 511. This permits for pivoting of the member 233 about the left end (as shown in FIGURES 1 and 2) of the pipe 511.

The cylinder 237 is operatively atached by a fluid conduit line 237A to the line 232. Accordingly, in operation of the apparatus 60 and 51 shown in FIGURES 16, 17, and 18, the pressure in line 232 (40–100 p.s.i.g.) provides that the shaft 238 will produce a fixed amount of torque against the cable 240 and thereby produce a continued constant torque on plate 241 and on the L 243 and tend to rotate the arm 233 counterclockwise (as shown in FIGS. 17 and 18) from its position shown in FIG. 17 to its position shown in FIG. 18 relative to line 232 and also from its position at the right in FIG. 1 to the position shown at the left of FIG. 1 and therefrom 1 to the position shown at right of FIG. 2 and therefrom 1 to the position at the left of FIG. 2.

In the cable position of FIGS. 16, 17, and 18 the pressure of the water in line 232 also is applied to piston 238 and rotates the pipe 233 counterclockwise relative to pipe 232 and thereby helps to move as well as rotate the pipes 232 and 233 from the position thereof shown to the left

of FIGURE 3 to the position shown in the right of FIG. 3; this action shown in FIG. 3 is continued when the apparatus **60** moves further right and downwards in the direction **49**. The continued forced rotation of line **233** relative to line **232** counterclockwise at either position of assembly **60** relative to assembly **51** and line **43** by use of the pressure in line **232** compensates for the frictional torque and avoids stress on the pipes **232** and **233** at joint **231** during movement of appaartus **51** down and/or up the field **40** as shown in FIGS. 1–3; cable **240** may be wrapped clockwise; i.e., on the top side as shown in FIGS. 17 and 18 and on the left side as shown in FIGS. 15 and 16 to notch **241**A in groove **245** as shown in FIG. 16 (rather than counterclockwise and on the opposite slide thereof as shown in FIGS. 15, 17, and 18) when movement opposite to that shown in FIGS. 1–3 is desired. In the operation of the apparatus **50** connector assembly **60** is connected to the pivot **270** at the end station **52** and a water-tight plug is put on the other end of line **511**, the end adjacent station **59**. Pump **45** is started and valve **44** opened and water from line **43** passes through assembly **60** into the pipe **511** and outwards therefrom at the sprinklers as **531** and **532** between the stations **52** and **53** onto field **40** and also thereonto from the similar sprinklers **541** and **542**, **551**, **552**, **561**, **562**, etc. Concurrently, water flows from line **511** through the line **121**. The normally open valve **122** permits water to pass therethrough to the T **161** and, therethrough, through adjustable valve **132** to the piston **134** in the assembly **74** and through line **75** for the wheel drive pistons at **96**B and **96**C in each of the intermediate stations and through line **163** for pistons **96** and **96**A to drive the corresponding wheels **94**B, **94**C, **94**, and **94**A.

The piston **134**, under the pressure of the fluid passing thereto from the valve **132** urges the piston **135** leftward from the position shown in FIGURE 24 to the position shown in FIGURE 25. The first step in such movement of the arm **135** leaves the adjustable positioning nuts **138** and **139**, as shown in FIGURES 24 and 27, out of contact with the shaft-holding slide or sleeve **137** on the arm **136**. Further movement leftward of the piston arm **135** brings the nut **138** into contact with the sleeve **137** as shown in FIGURE 28. On continued movement of arm **135** and continued contact of the nut **138** with the sleeve **137** the arm **136** is rotated clockwise to the position shown in FIGURE 29. At this point; i.e., at the position shown in FIGURE 29, the nut **138** on the shaft **135** has urged arm **136** counterclockwise to the position whereat the arm **136** is vertical. The arm **141** is, at this point, just then contacted at its ear **148** by the lower portion of the arm **136**. Further motion leftward of the piston **135** to the position generally shown in FIGURES 25 and 30 results in that the arm **136** moves the ear **148** to the point shown in FIGURE 30 at which the arm **141** is vertical and compresses the spring **156** because the arm **136** has engaged the ear **148** and pushed and rotated the ear **148** and arm **141** about the pin **142** to such a degree that the arm **141** is then substantially vertical and the previously diagonal spring **156** is vertical. The subsequent slightest leftward motion of the shaft **135** at this point; i.e., toward the position shown in FIGURE 31 results in that the arm **141** is rotated at its lower portion clockwise of its previous position shown in FIGURE 30 and is tilted downward and slightly to the left. Thereupon, the compressed compression spring **156** expands and, with a snap action rapidly snaps and/or urges the arm **141** in the clockwise direction (as shown in FIGURE 31) and results in that the ear **148** of arm **146** is rapidly moved out of contact with the arm **136**. In the resulting position of parts, which position is shown broadly also in FIGURE 26, the C-shaped arm **146** of the link arm **141** is out of contact with the arm **136**.

On completion of this above described slow-then-snap-action motion of the arm **141** from the position shown in FIGURES 24 and 27 to the position of arm **141** as shown in FIGURES 31 and 26 the concomitant movements of link arms **191**, **192**, **193**, and **194** with arm **141** rapidly change their position relative to the valves **122** and **127**. This rapid or snap change in position of those arms results in that the normally open valve **122**, open in the position shown in FIGURE 24, is rapidly and firmly closed and the valve **127**, closed in the position shown in FIGURE 24, is rapidly opened. This opening of the valve **127** results in a flow of water from portions of the hydraulic system in assembly **74** and line **75** then open to the line **128**, in particular, the content of the piston **134** (which has the same structure as shown for piston **96** in FIGURES 19 and 20) previously to the right of the piston plate in that piston and a fall in pressure in line **75** and below valve **122**. More particularly, a volume equal to that portion of water previously in the chamber of piston **134** is displaced via line **131**, valve **132**, line **125**, valve **127** and line **128** to line **158** (which line **158** is attached to line **511** between stations **52** and **53**) and this water is discharged to the ground while valve **122** is kept closed.

Also, this fall in pressure below valve **122** causes the pressure in line **75** to fall and the valves, as **80**B and **80**C, to open and the wheel pistons as **96**B and **96**C to contract all along assembly **51**.

With the loss of this discharge pressure, the supplemental piston return spring **154** which is attached to the nut **138** and is a tension spring attached to the arm **135** (and a spring in piston **134** corresponding to spring **967** in piston **96**) begins to draw back the arm **135**: nut **139** moves toward slide **137** as soon as the pressure to the rear side (right in FIGURES 24–35) of the piston **134** falls when arm **135** is then moved counterclockwise from the position shown in FIGURE 31 to the position shown in FIGURE 32 whereat the nut **139** engages the slide **137**.

Continued contraction of the spring **154** urges the nut **139** and the slide **137** and the arm **136** further counterclockwise to the position shown in FIGURE 33 and, thereafter, the spring **154** urges the arm **141** to the position shown in FIGURE 34 and the spring **156** is again compressed preparatory to a snap action release and movement of arm **141**.

In the position shown in FIGURE 33 the arm **136** is vertical but does not yet engage the ear **147** of the arm **146** of the arm **141**. On further counterclockwise motion of the arm **135** relative to the position shown in FIGURE 33 the arm **136** engages the ear **147** of the arm **141** and moves arm **141** from the downward and leftward position shown in FIGURE 33 to the vertical position shown in FIGURE 34 and compresses spring **156**. On further rightward motion of the arm **135** the arm **141** is tilted downward and slightly to the right. At this position the spring **156** is released and operates against the bottom of the arm **141** to rapidly drive the arm **141** all the way to the right. This snap action quickly brings the arms **136** and **141** to the position shown in FIGURES 35 and 24 and this rapid snap action terminal movement of the arm **141** concurrently brings the arms **191**, **192**, **193**, and **194** to the position thereof shown in FIGURE 24. At that position valve **127** is then closed and the valve **122** is then opened and fluid again flows from the line **121** through valve **122** into the line **161** and also into the line **75** to the stations as **53–58**. At this point an interrelationship below described between the operation of the drive wheel assemblies **72** and **73** on the end station **52** and drive wheels of the intermediate stations becomes effective as well as with assembly **76**.

The pacemaker control subassembly position controls the opening and closing of the valve **165** as above described. Accordingly, when the valve **122** is open that flow of liquid which would normally pass through lines **163** and **166** to lines **106** and **106**A to the wheel cylinders **96** and **96**A is controlled by the valve **165**. The operation of the valve **165** is determined at arm **188** by the position of the wheel **94**E relative to wheel **94** and frame **76**. Because of the firm yet pivotal attachment of the arm

170 to the yoke 92 and the similar firm pivotal connection permitting rotation only in one plane of the arm 170 relative to arm 176 and the rigid connection of the arm 176 to the yoke 177, the wheel 94E tracks along in a vertical position to the rear of the wheel 94. The distance between wheels 94 and 94E is determined by the relative speeds of the wheels 94E and 94.

Fluid passes through the T 161 to the lines 180, 181, 182, and 183 to the valve 96E and wheel cylinder 96E when the valve 133 is open and the valve 127 is closed; the piston of the cylinder 96E then is urged forward and it urges its link 99E against wheel 94E and urges the wheel 94E forward. However, as above explained and shown also in FIGURE 37, the link arm 99E doesn't move quite as far (only 80% as far) as the maximum travel of the link 99 (FIGURE 10). Accordingly, the limited travel of the wheel 94E controls the potential travel of the wheel 94 by the action of the subassembly 76 on the valve 165. However, concurrent with the pulses of pressure to piston 96E, the pulses of pressurized liquid in line 75 passes via lines, as 214 and 216, to the wheel piston subassemblies, as 96B and 96C, that drive the drive wheels, as 94B and 94C, of each of the intermediate station, as 53. However, if any one station such as station 57 in FIGURE 5 should get ahead of the other stations, as 58, 56, and 55, because of a downhill situation or of mud everywhere else except in the path of that particular station 57, the automatic movement of the control arm 220 by line 230 cuts off flow to the wheel pistons thereof by the control valve in each such subassembly, such as valve 215 in station 53. When the station, as 54, is behind all the other stations the control arm therefor such as 220 automatically is moved by line 230 to a position such as shown in FIGURE 22 which keeps the control valve therefor (as 215 in station 53) open.

In a situation as shown for station 57 in FIGURE 5 the control arm of that station is located in the retard position (as is shown for station 53 in FIGURE 21) and the valve for that particular station 57 is closed and the drive wheels of that particular station are not moved until the control arm position therefor is changed.

Accordingly, the path of each substation as 53, 54, 55, 57, 58, is controlled by the periodic pulses provided to the line 75 by the subassembly 74. The speed of apparatus 51 depends on the size and frequency of stroke of links as 99 (about five inches for wheel 94 on each full stroke of pistons 96 and 96A in the exemplary embodiment). The number of strokes of links and of pistons, as 96 and 96E, is controlled by the subassembly 74. The speed of the subassembly 74 is controlled by the valve 132. Opening the valve 132 wide results in a movement of the piston 134 from its fully retracted position shown in FIGURE 24 to its fully extended position shown in FIGURE 26 and the return to the FIGURE 24 position rapidly. A smaller opening of valve 132 results in a slower filling of the piston 134 and a slower rate of operation of assembly 74. The exemplary embodiment 51 hereinabove described provides for a range between 40 seconds and 200 seconds for a complete cycle (from position of FIGURE 24 to that of FIGURE 26 and back) of the subassembly 129 of the assembly 74 and, accordingly, of each of the power driven wheel subassemblies in the apparatus 51 and for fixing the time of cycle to +2 seconds by valve 132.

A description of the overall operation of the apparatus 51 as shown in FIGURES 1, 2, and 3 follows:

In operation the apparatus 50 which comprises the connector assembly 60 and the sprinkler apparatus 51 is pivotally attached to the valve 44 by joints 235 and 270. Pressurized water at 80 p.s.i. passes from the pump 45 via line 43 and valve 44, through the connector assembly 60 to the sprinkler element 51 pivotally connected to arm 233. The timer subassembly 74 of the end station 52 provides for, as above described, driving the pacemaker wheel 94E. The speed of the pacemaker wheel 94E determines the actuation or lack thereof of the drive wheels assemblies 72 and 73 of the station 52. The frame 70 has attached thereto at its cross brace 84 one end of the control wire 230. The wire 230 passes through a pivotally mounted control element such as 220 on the frame as 78 of each of the intermediate stations, as 53 to a member 84G on station 59.

The wheel subassemblies as 72 and 73 of each station, as 52 are located (by pin as 922) relative to the frame as 70 of each station with the plane of rotation of the wheels thereof transverse to the direction of length of pipe 511. Valve 44 is opened and the stations of the assembly 50 all move transverse to the direction of the pipe 511. The speed at which each station operates at any one moment is dependent on the traction of the wheel subassemblies of each such station make with the ground therebelow. The sprinklers as 531, 532, 541, 542 on line 511 spray water in equal and overlapping circles, as 401, 402, 403, 404. On movement of the apparatus 50 in direction 48, the water is distributed over field 40 in overlapping rectangular strips, as 411, 412, 413, 414; such strips are elongated in the direction of motion of the apparatus 51 and completely and evenly cover the portions of the field traversed by assembly 51.

If any one station, as 54 in FIGURE 5, lags behind the others the control arm thereof corresponding to arm 220 of subassembly 53 thereof is moved to a position such as in FIGURE 22 which causes the valve corresponding to valve 215 of subassembly 53 to be opened and the wheels thereof to be advanced by the passage of water from the lines 75 to the pistons, as 96B and 96C of the wheel subassemblies as 62 and 63 of each of such intermediate station. When one assembly, as 57, in FIGURE 5, is ahead of the other stations of assembly 51 in the path of travel of the assembly 51 the control arms corresponding to arm 220 of that station 57 is moved by wire 230 to a position as in FIGURE 21 which cuts off the supply of fluid power to the wheel drive pistons of the drive wheel assembly of that particular station. Accordingly, the stations in retard of the others are fed fluid power until they reach a position at which such theretofore retarded station and the stations adjacent thereto are all advancing at the same average speed.

This shut-off is a complete shut-off for any one cycle and, for such cycle which ranges from 40 to 200 seconds there is no motion of that station. When a station is generally in line with the others of assembly 51, it moves forward together with the other stations.

The above description covers the movement of the stations of the apparatus generally in a straight line, but does not necessarily provide that the line of stations is always transverse to the length of the field, as 40, being traversed thereby. The feature that the apparatus 51 automatically marches in a line transverse to the length of the field is guaranteed by that the end stations 52 and 59 do have the same structure and valves 132 and 132G are adjusted to drive their stations at the same speed. As the end stations travel at the same speed, this provides that, with the intermediate stations being in a straight line between those two end stations, that the entire apparatus 51 and 60 will travel down the field as 40 transverse to the length thereof.

According to the above, the components of the station 59 are identical to those of 52 except for the pivotal connection of 52 to the connector pipe 233 at any one setting and a plug in pipe 511 lateral to station 59 so the pipe 511 is closed lateral to station 59. As below described, the station 59 can also connect to the connector assembly 60 as well as can the station 52, as shown in FIGURE 3.

The above control of speed of operations of the substations of the assembly 51 provide for a movement of pipe 511 transverse to the length of the field of the entire apparatus 51 during its sprinkling operation and an even sprinkling of that field (41).

After the sprinkler apparatus 51 has moved the entire length of extent of assembly 60 from one portion thereof

extended to the right, as shown in FIGURE 1 to the position thereof fully extended to the left, as shown in FIGURE 2, the valve **44** is closed, the assembly **60** is disconnected at the disconnect coupling **267** and the coupling **267** of assembly **60** connected to a valve as **44A** spaced away from valve **44** up to about 180% the full extended length of assembly **60** along pipe **43**.

On reaching one end of the field **40** the yoke as **92**, of each wheel assembly, as **73**, may be rotated 90 degrees as shown in FIGS. 6 and 13. Pivot shafts as **921** atop of each yoke and the releaseable pin there, as **922**, permit the shafts of the yokes **92** to be rotated to and held in a position with the plane of rotation of the wheels as **94** and **94E** transverse to that shown in FIGURE 10. This provides for the transverse location of each yoke as **92** and the wheel therewith for all stations, as **52–59**, of assembly **51**. As the subassembly **76** is attached to a portion of the yoke **92**, it is accordingly then moved to a position parallel to the plane of rotation of the wheel **94** as shown in FIGURE 6. Similar relationships hold with the corresponding portions of the other end station, **59**.

When the subassembly **51** has been moved from field portio **41** to the location on the other side, **42**, of the field **40**, as shown in FIGURE 3, arm **170** of the subassembly **76** is disconnected at pin **971** from the lug **97** and attached onto a corresponding lug on the yoke **92A**. A corresponding lug **97A** is provided on the yoke **92A** of the wheel subassembly **72**. This provides, as shown in FIGURE 3, for the location of the member **170** on the yoke **92A**. The hose connections of the pacemaker subassembly **76** are unchanged in their hydraulic operation, the hose **180** merely wrapping around the hose **121** and reaches readily to the other side of arm **90** and performs its same function of controlling, at valve **165**, the flow of water from Tee **124** to pistons **96** and **96A** when, as shown in FIGURE **3**, the wheel assemblies, as **72** and **73**, of each station of assembly **51** are arranged to move opposite to the direction of movement of the stations shown of FIGURES 1, 2, 4, and 5.

During motion of the apparatus **51** from the position shown in FIGURE 2 to the position shown in FIGURE 3 by transverse setting of the wheels as shown in FIGURE 6 the motor power for such movement is provided by a conventional tractor which is attached to and pulls one end station, i.e., **52** and pipe **511** of the apparatus **51**.

The alteration of the apparatus **51** from the connections provided for movement upwards and to the left, as in FIGURES 1 and 2, to the position for moving in the opposite direction, i.e., in the direction downward and to the right as shown in FIGURE 3, are (1) assembly **60** is connected by the pivot joint **270** to the end of pipe **511** adjacent station **59** and the end of pipe **511** adjacent station **52** is plugged, and (2) the control line wire **230** (which extends from the arm **84** of subassembly **52** to the coresponding arm **84G** on the other end station, **59**) is at each intermediate station moved from the lower slot **226** of control arm as **220** as shown in FIGURE 22 to the upper slot **222** of arm **220** as shown generally in FIGURE 7. A station, as **54**, which would be to the right of the line of stations as shown in FIGURE 5 and generally to the rear of the apparatus **51** during its motion upward and to the left (direction **48**) while remaining in the same relative position would, on movement downward and to the right, be forward of the remainder of the stations in the assembly **50**. This movement of line **230** on reversal of motion of apparatus **51** provides that the power through the control valve (as **215** of station **53**) of such station **54** be cut off (rather than permitted) on movement as shown in FIGURE 3. This structure of arms as **220** permits that a station, as **57** of FIGURE 5 which (on moving upward and to the left and being in advance of the line of stations would have no power sent it according to the arrangement shown in FIGURE 21) would, by reversing of the motion of the assembly **51** to move downward and to the right as in FIGURE 3 and movement of line **230** to the upper slot of control arm **220**, provide for supplying full flow of hydraulic power to the wheel subassemblies of that station when in the relative position shown in FIGURE 5. The cut-off is effective in the same manner as such power is cut-off when the arm **220** reaches the orientation shown in FIGURE 21. (The orientation shown in FIGURE 21 is that provided on a station as **57** during the disposition of the substations as shown in FIGURE 5 during travel upward and to the left). Accordingly, the control apparatus **225** of this invention (frames as **78**, wire **230**, arms as **220** and **84**, valves as **215**) provides for control of the action of the drive wheel piston subassemblies of each station during motion thereof in either direction transverse to the length of the pipe **551**.

The apparatus shown in FIGURE 16 is the same as in FIGURE 15 generally, except that there is no truss structure, as **357**, provided in assembly **67** of FIGURE 16 and the arms **243A** and **268** of FIGURE 15 are substantially shortened. Accordingly, the arm **233** of assembly **67** does not automatically pass over the arm **232** and the arm **233** is provided with a separate wheel structure **288**, identical to **234** and firmly attachable to and supporting pipe **233** (in **67**) for its movement parallel to the pipeline **43**. Structure **288** may be detached from pipe **233** for a short distance to permit pipe **233** to pass over pipe **232**. At each station the frame as **70** as above described provides for locating the pipe **511** on member **36** for support rather than on the transverse support arm **851** shown therefor in FIGURES 9, 11, 12 and 14. This provides that the pipe **511** may ride on correspondingly high supports. as **84** and **84B**, for the entire length of the apparatus **50** and thereby be at a greater height, which is particularly useful when watering relatively high crops.

It is within the scope of this invention that the connector subassembly **60** may be used with other apparatuses and also, that the apparatus **50** may be used with other connectors that will connect it to the pipeline **43**. It is, however, particularly beneficial to use the apparatus **60** because the piston **237** thereof makes use of the hydraulic power in the pipe to facilitate the turning of the upper pipe **233** with respect to the lower pipe **232**.

Additional dimensions of the exemplary embodiment are given in table below.

Each transverse pipe support arm, as **851** on station **52** is firmly yet adjustably locatable vertically anywhere on arms **82** and **83** on the corresponding frame of all the stations of assembly **51** for firmly locating and supporting pipe **511** at any desired height in that range.

TABLE

Item measured	Identity or point to point distance	Measurement
Arm 98	Pin 991–971	7″.
Do	Pin 971–981	3½″ (Fig. 10).
Spacing	83–84	2½ ft.
Height	84 ground	43″.
Frame 70	84–86	8′8″.
Size of members	84	2″ steel angles.
Diameter	94	28″.
Width	Rim 9	5″.
Height of cleat	103	¾″.
Station spacing	52–53	20′.
Do	58–59	20′.
Do	53–54	40′.
Diameter	232	6″.
Do	511	6″.
Length 232	C.L. 231 to C.L.[1] 235	30′.
Length 233	C.L. 231 to C.L. 270	40′.
Stroke	135	2½″.
Length 135	C.L. 142 to C.L. 156	18″.
Pipe size	125	2″ i.d.
Length	176	5′8″.
Piston diameter	96	7″.

[1] C.L.=center line or vertical axis of pivot joint.

While above described, for versatility of control, a timer assembly (**74** and **74G**) is shown on both stations **52** and **59**, only one timer assembly **74H**, identical to **74**, may be used and it be located on an intermediate station (shown as **56** in FIGURES 2, 4, 5, and 6); then the timer assemblies on the end stations as **52** and **59**

will not be provided. Thereby, one timer is provided for the entire apparatus **51**. In this situation the water from the line **43** comes to the main line **511** and passes therethrough to a line **121H** which feeds timer **74H** located at such intermediate or middle station. The line **75** is then connected as shown in FIGURE 7 to the cross **124** at the bottom of the assembly **74H** and this line **75** goes to all the other stations and operates the drive wheels of those stations as above described.

The use of two separate timer subassemblies, one (**74**) on station **52** and the other (**74G**) on station **59**, as above described, provides that there may be a controlled variation or fixed ratio of speeds of those two stations; in the hereinabove described apparatus **51** using only one timer subassembly (**74H**) the same pulse of fluid will go to all the stations of apparatus **51** during the operation of the machine and assures that each of the stations on the assembly **51** will travel at the same speed and in a straight line as above described.

It is also within the scope of this invention that an additional pacemaker assembly **76H**, identical to **76**, shown in the drawings as attached to an assembly **56**: **56** is, in the actual embodiment, located in the middle of the entire assembly **51**.

The pacemaker wheels assemblies as **76** and **76G** and **76H** assure that the station to which such pacemaker subassembly is attached, (such as station **52** for pacemaker subassembly **76**, station **59** for subassembly **76G** and station **56** for an additional pacemaker subassembly **76H**) each travel at a speed controlled by that pacemaker assembly. The controlled speed of each such station is that at which it is controlled by its pacemaker subassembly. The pacemaker subassemblies of assembly **51** are identical. The speed at which each station attached to an identical pacemaker subassembly travels is, accordingly, the same. The control subassembly **225** assures that the stations between the stations that do not have pacemaker subassemblies travel at the same speed as those stations that have the pacemaker subassemblies.

Where one timer assembly, as **74H**, is used this third pacemaker subassembly **76H**, (which is identical in operation to the pacemaker assembly **76** above described for station **52** and also identical to pacemaker assembly **76G** for attachment to station **59**) provides for closer control for straight line advance of the assembly **51** in a direction transverse to the length of the pipe **511** than with two pacemaker assemblies.

As above taught, col. 16, lines 54–62, the link arm **99E** moves only 80% of the travel of the link **99**. The advantage of this 20% difference is that any stations on the assembly **51** may lag in average travel for a period of time by 20% of the travel of other stations of assembly **51** and its alignment relative to the remaining station of the apparatus **51** be closely and effectively controlled. In the preferred embodiment the end station pacemakers (and the intermediate pacemakers, as **76H**) provide for 80% ratio of potential linear travel of the pacemaker wheel as **94E** to the potential travel of drive wheels as **94** and **94A**.

However, other ratios between those wheels are within the scope of this invention such as 50% to 90% but for practical purposes the 80% is preferred.

The hydraulic engine timer subassembly **474** shown in FIGURES **38** to **44** is firmly supported on arms **82**, **83** annd **84** of frame **70** of end station **52** in lieu of subassembly **74** above described. The engine timer subassembly **474** comprises a valve subassembly **460** and a piston and link and spring subassembly **429** operatively connected; the assembly **474** cooperates with the pacemaker control subassembly **76** exactly as does assembly **74**.

Subassembly **474** is directed to providing and does provide a repeated periodic hydraulic pulse for all the drive wheels of all the stations of assembly **51**. A subassembly **474G** of station **59** (similar to **474** of station **52**) also provides a periodic pressure pulse for driving all the drive wheels of all the stations of assembly **51**. The utilizaton of the pulse to move each station by the drive wheel mechanism of that station depends, in the exemplary embodiment, on the position of that station relative to the other stations of assembly **51** and is controlled by the wire **230** and control arms, as **220** on station **53**, for that station.

The valve subassembly **460** comprises a left hand wall **461**, which is imperforate except for the discharge orfice **476** therein; a top wall **462** which is imperforate, a right side wall **463** which is imperforate except for the intake orifice **473** and the power discharge orifice **472** therein; a bottom wall **464** and orifice **469** therein; a front wall **477** and a rear wall **478** both of which are imperforate except for the holes therein for the passage of the shaft **442** therethrough.

The walls **461** to **464**, **477** and **478** define a chamber **470**. Within the chamber **470** is a left diagonal baffle **465** which extends rightwards and upwards (as shown in FIGURES 43 and 44) from below the orifice **474** toward the wall **462** and is firmly attached thereto and to walls **477** and **478**. Wall **465** has therein exhaust orifice **466** for a valve closure **457**. Another drive chamber baffle **467** is located at lower right corner of chamber **470**, it has located therein drive valve orifice **468** for a valve closure **458** therein. A rigid valve pivot control shaft **442** is firmly located in and supports a collar **455**. Collar **455** is held by a conventional spline **459** to shaft **442**. Collar **455** firmly supports a pair of rigid diametrical arms **451** and **453**. Arm **451** holds a valve stop **457** at its end, and arm **453** supports the valve stop **458**. The intake opening **473** is, in this particular embodiment, connected by the fitting **421** to the inlet line **121** of the apparatus **50**, the drive outlet orifice **472** is connected by the fitting **475** to the power discharge line **75** of the apparatus **50** and the exhaust orifice **476** in the wall **461** of subassembly **460** is operatively attached by fitting **428** to the discharge line **128** of the apparatus **50** in place of the elements of subassembly **74** connected to lines **121**, **75** and **128**. A line **431** is connected to the orifice **469** in wall **464**, and that conduit **431** connects the orifice **469** to an adjustable valve **132** (same as in embodiment **51**); line **131** connects to the drive chamber **482** in the interior of hydraulic piston **430**.

On operation of subassembly **474**, in the counterclockwise rotated position of the arms **451** and **453** (shown in FIGURE 43), liquid from the line **121** passes through the chamber **470** and into and past valve closure element **458** into the line **475** and chamber **482** of piston **430**. In the clockwise rotated position of the arms **451** and **453** (shown in FIGURE 44) water from line **121** and fitting **421** passes through orifices **473** and **466** through orifice **476** and to line **128** in fitting **428**. Otherwise the operation is as above described for the apparatus **50**.

The location of valve closure element **457** and **458** are determined by the position of the snap link and spring subassembly **429**. The snap link and spring subassembly **429** has its position determined by the flow of water in and out of the piston **430**.

The snap link and spring subassembly **429** comprises a T shaped snap link lock arm **440** and a drive bracket **436**. Arm **440** is formed of a lower rigid vertical portion **441** which is firmly attached at its bottom to the shaft **442**, and a rigid horizontal arm **446** which is firmly attached to the top of arm **441**. The horizontal arm **446** is provided at each of its ends with an ear, a left **447** and a right ear **448**; these ears each embrace and engage with the left arm **436A** of drive bracket **436** as below described and as shown in the drawings.

The drive bracket **436** comprises a rigid left vertical arm **436A** firmly attached at its top to a rigid horizontal arm **436B** which is in turn firmly attached at its right side to the top of a rigid right vertical arm **436C**. Arms

436A and 436C are each pivotally attached at their lower end to the shaft 442 as is shown in FIGURE 42.

The piston 430 is generally identical with the piston 130 shown in FIGURES 24, 25 and 26.

Piston 430 comprises a shell 480 with a movable piston plate 483 and an annular piston seal 481. Piston 483 is firmly attached to the shaft 435, the piston plate is held by flexible seals 481 and forms a water-tight chamber 482 with one side of shell 480 shaft 435 is slidably held in sleeves 437A and 437B. Shell 480 and sleeves 437A and 437B are firmly held on arm 84.

Piston 430 drives its piston shaft 435, corresponding to shaft 135 of piston 130, to the right through sleeves 437A and 437B. Sleeves 437A and 437B and piston 430 and subassembly 460 are firmly fixed to the arm 84 of the apparatus 52. A return drive spring 450 is attached at one end to the free end of shaft 435 and at the other end to a lug 449 on the shaft 84. This spring serves to move the arm 435 leftwards (as shown in FIGURES 38 to 41) except when the force of such spring is overcome by the action of water in the piston 430.

A rigid yoke 433 is supplied with set screws and is firmly attached thereby to the shaft 435 and is pivotally seated in arms 436A and 436B. Yoke 433 and bracket 436 are moved from the leftward position shown in FIGURE 38, through the positions shown in FIGURES 39 and 40 to the rightward position shown in FIGURE 41 by piston 430 and spring 450. The action of the snap link assembly 429 is generally very much the same as that shown for the assembly 129 in FIGURES 24 to 36. One, lower, end of a tension spring 456 is firmly attached to a bracket 464B extending laterally of the wall 464 and is located vertically below the shaft 442. The other end of that spring is attached to a bracket 446A at the center of the arm 446 and is always in tension.

In operation of assembly 474 as the water pours into assembly 460 and piston 430 from line 511 the piston plate 483 of piston 430 moves shaft 435 to the right as shown in FIGURES 38 to 41 and the arm 436A rotates in a clockwise direction as shown in the movement of that arm from the position shown in FIGURE 38 to that shown in FIGURE 39 to that shown in FIGURE 40. This motion of the arm 436 and the arm 446 moves the arm 441 and the shaft 442 from the position shown in FIGURE 38 to the "teeter" position of arm 441 as shown in FIGURE 40. Any further clockwise motion of the arm 436, as from the position thereof shown in FIGURE 40 to that shown in FIGURE 41, causes the spring 456 to snap the arm 446 to its most clockwise position as shown in FIGURE 41. The motion of bracket 436 is lightly opposed by the spring 452, which spring is as shown in FIGURE 42, attached to the base of assembly 440 by a bracket 464A.

Shaft 442 and valve closure 457 and 458 are thus driven by the piston 430 to turn quickly from their most counterclockwise position as shown in FIGURES 38 and 43 to their clockwise position as shown in FIGURES 41 and 44.

FIGURE 43 shows the interior relationships of the elements of subassembly 460 during the positions of its interior parts when its exterior parts are in position as shown in FIGURE 38 while FIGURE 44 shows the interior relationships of the elements of apparatus 440 during the position of the external parts thereof shown in FIGURE 41.

On completion of this clockwise rotation of the arm 440 and opening of the valve closure 457, piston 430 empties through orifices 469 and 466 and 476 and the piston discharge line 128. Spring 454 then urges shaft 435 leftward and, when arm 436 has moved counterclockwise as shown in FIGURES 38 to 41, it causes arm 41 to rotate counterclockwise from the clockwise position of FIGURE 41 to the "teeter" position as shown in FIGURE 40 and spring 450 thus returns arm 441 and shaft 442 to the full counterclockwise position as shown in FIGURES 38 and 43. Water from line 511 then passes from input line 121 to drive orifice 472 of apparatus 474 and line 75 of apparatus 50 as above described therefor and into chamber 482, so piston 430 drives against shaft 435 to the right and the above cycle of operations of parts moving arm 441 from the position of parts shown in FIGURE 38 to the position of parts shown in FIGURE 41 is repeated. The rate of such repetition is governed by the setting of valve 132 as above described for the assembly 74.

Assembly 460 is supported from arm 84 by bracket 84A; piston 430 is firmly supported by bracket 430A; brackets 430A and 84A sleeves 437A and 437B are firmly supported in arm 84.

We claim:

1. A sprinkler connector assembly comprising a first conduit pipe and a second conduit pipe pivotally and hydraulically joined together at a joint with a vertical axis, said first conduit having an annular ring firmly attached thereto at said joint, a piston chamber fixed to said first conduit and hydraulically joined to the interior of said conduit, a movable piston in said chamber operatively mechanically connected to a connecting means that is attached to the periphery of said annular ring and movable therewith about said vertical axis of said joint.

2. An apparatus as in claim 1 wherein said first conduit is supported by rotatable ground engaging wheel and said second conduit has firmly attached thereto a truss structure that supports it from one end to the other and comprises a truss compression structure means near its middle, tension means extending from the bottom of said truss compression member to one end of said first conduit and another tension member extending from the other end of said conduit to the bottom of said truss compression structure.

3. An apparatus for irrigating a field comprising the combination of a series of pipe supporting stations spaced apart along and joined to a sprinkler pipe, said series of stations comprising a plurality of intermediate stations and two end stations, each end station being lateral of the intermediate stations, each station comprising a vertically extending main frame and a pair of ground engaging drive wheels rotatably attached to said main frame, a hydraulic piston operatively attached to at least one of said wheels, and a hydraulic drive wheel conduit line operatively attached to said piston, each lateral end station of said series comprising also a hydraulic timer assembly and a speed control assembly;

said speed control assembly comprising a drive piston, a third ground engaging wheel, and an extensible frame, said extensible frame firmly supporting said piston and said third wheel, said drive piston engaging and driving said third wheel, said extensible frame being attached to said main frame, said third wheel spaced away from said wheel on said main frame, and a valve control means operatively connected to the drive wheel piston conduit of said end station supported on said extensible frame and sensitive to the degree of extension of said extensible frame, said timer assembly being operatively attached to said drive wheels on said end station through said control valve on said extensible frame; and also comprising

an intermediate station control valve means firmly supported on the main frame of each intermediate station and a hydraulic line extending from said timer assembly on said one end station along said sprinkler pipe and supported thereon to each of said intermediate stations and, at each of the said intermediate stations there connected to the intermediate station control valve means thereof, said intermediate control valve means being connected to the hydraulic drive wheel conduit line attached to the hydraulic piston which is attached to the ground engaging drive

wheel on said intermediate station, a rigid valve control link pivotally mounted on the main frame of each intermediate station in the same relative position on each intermediate station and operatively connected to the intermediate station control valve on said station and a cable means extending from one end station to the other end station and extending across several intermediate stations, said cable means extending from one end station to the other and engaging the control link of each intermediate station, wherein said speed control assembly comprises a first rigid member pivotally attached to said main frame, a second rigid member pivotally attached to said first member, a wheel yoke firmly attached to said second member, a ground engaging wheel rotatably attached to said yoke, a hydraulic piston firmly supported on said yoke and operatively attached to link means operatively attachable to said ground engaging wheel, a hydraulic conduit line extending from said timer assembly to said piston on said yoke, said link means between said piston and said control assembly wheel having a stroke substantially smaller than the stroke of the piston assembly of the said ground engaging wheels on said main frame of said end station and pivot supporting means at the front and rear end of the main frame of each end station for engagement with the first rigid member of said speed control assembly, and wherein the said timer assembly comprises a valve subassembly and a piston and link subassembly operatively connected,

the valve subassembly comprising a valve chamber shell, an inlet orifice in a first valve outlet orifice and a second valve outlet orifice in said valve chamber shell, said valve orifices being spaced from each other, a valve support shaft pivotally supporting a rigid valve support arm means in said chamber shell, said valve support shaft means being supported at least in part in a wall of said chamber shell and a portion of said valve support shaft means extending outward of said valve chamber shell through said wall,

a first valve closure member for and fitting said one valve outlet orifice and a second valve closure for and fitting said second valve outlet orifice, said arm means on said valve support shaft in position thereof supporting said first valve closure in and closing said first outlet orifice and then holding the second valve closure means spaced from said second valve outlet

orifice so that said second valve outlet orifice is open, said arm alternatively holding said first valve means in a second position thereof spaced from said first valve orifice so that it is open and then holding said second valve closure means in and closing said second valve outlet orifice,

the piston and link assembly comprising an expansible piston assembly and a link assembly, said piston assembly comprising a piston chamber shell, a piston in said chamber, a rigid piston shaft attached to said piston and extending beyond said piston chamber shell, said piston and a portion of said piston chamber shell defining an expansible piston chamber, said expansible piston chamber being operatively connected to the interior of said valve chamber,

a valve control arm firmly attached to said valve support shaft exteriorly of said valve chamber, and a means attached to said valve control arm and urging said arm and said valve support shaft into said one position or said second position of said valve support shaft,

said piston shaft being operatively connected to said valve control arm for movement thereof between said one position and said second position thereof.

4. Apparatus as in claim 3 wherein a conduit line is operatively connected to said expansible chamber and to said valve chamber and an adjustable valve is located in said conduit line.

5. Apparatus as in claim 4 wherein said piston shaft is connected to a rigid arm with a pivotal connection to a point fixed relative to said valve chamber and operatively connected to rotate said rigid arm about said pivotal connection, said rigid arm contacting said valve control arm and moving it to and from said first or said second position thereof.

References Cited

UNITED STATES PATENTS

2,726,895	12/1955	Behlen	239—212 X
2,940,672	6/1960	Caskell	239—212
3,072,268	1/1963	Purtell	239—212 X
3,255,968	6/1966	Stafford	239—212

ALLEN N. KNOWLES, *Primary Examiner.*

BERNARD BELKIN, *Assistant Examiner.*

U.S. Cl. X.R.

137—344; 239—178, 184, 213