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[54] **IRRIGATION APPARATUS**

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[73] Assignee: **Valmont Industries, Inc.**, Valley, Nebr.

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[51] **Int. Cl.**[3] **A01G 25/09**

[52] **U.S. Cl.** ..... **239/177 R**; 239/710; 239/DIG. 1

[58] **Field of Search** ..... 239/177, 178, 184, 191, 239/192, 254, 710, 711, 719, 721, DIG. 1

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[57] **ABSTRACT**

Self-propelled irrigation apparatus for watering non-circular areas includes a main arm assembly pivoted at one end and supported at intervals by self-propelled support towers. An extension arm assembly is mounted on self-propelled support towers and has one end pivotally connected to the free end of the main arm assembly for irrigating portions of the field outside the circular area traversed by the main arm. Electrical control means are provided to rotate the extension arm assembly relative to the main arm assembly as the latter rotates.

39 Claims, 8 Drawing Figures

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FIG. 1

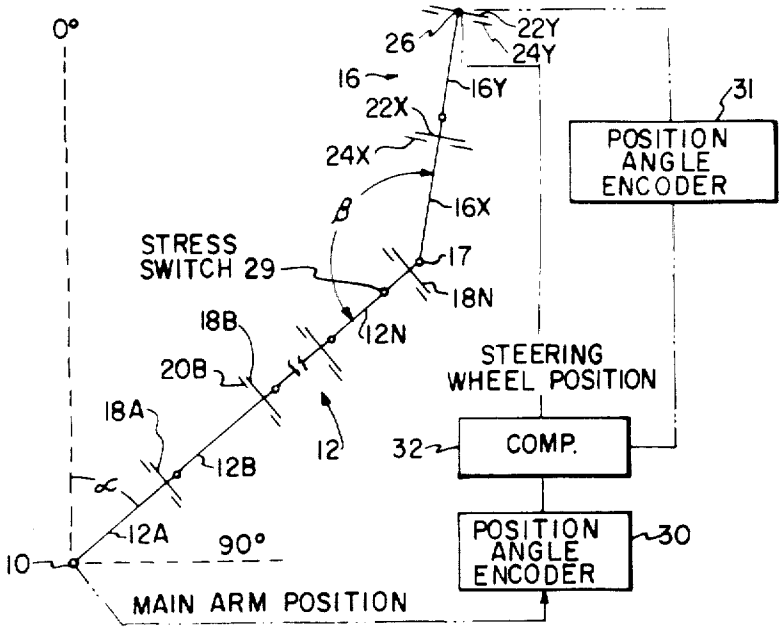
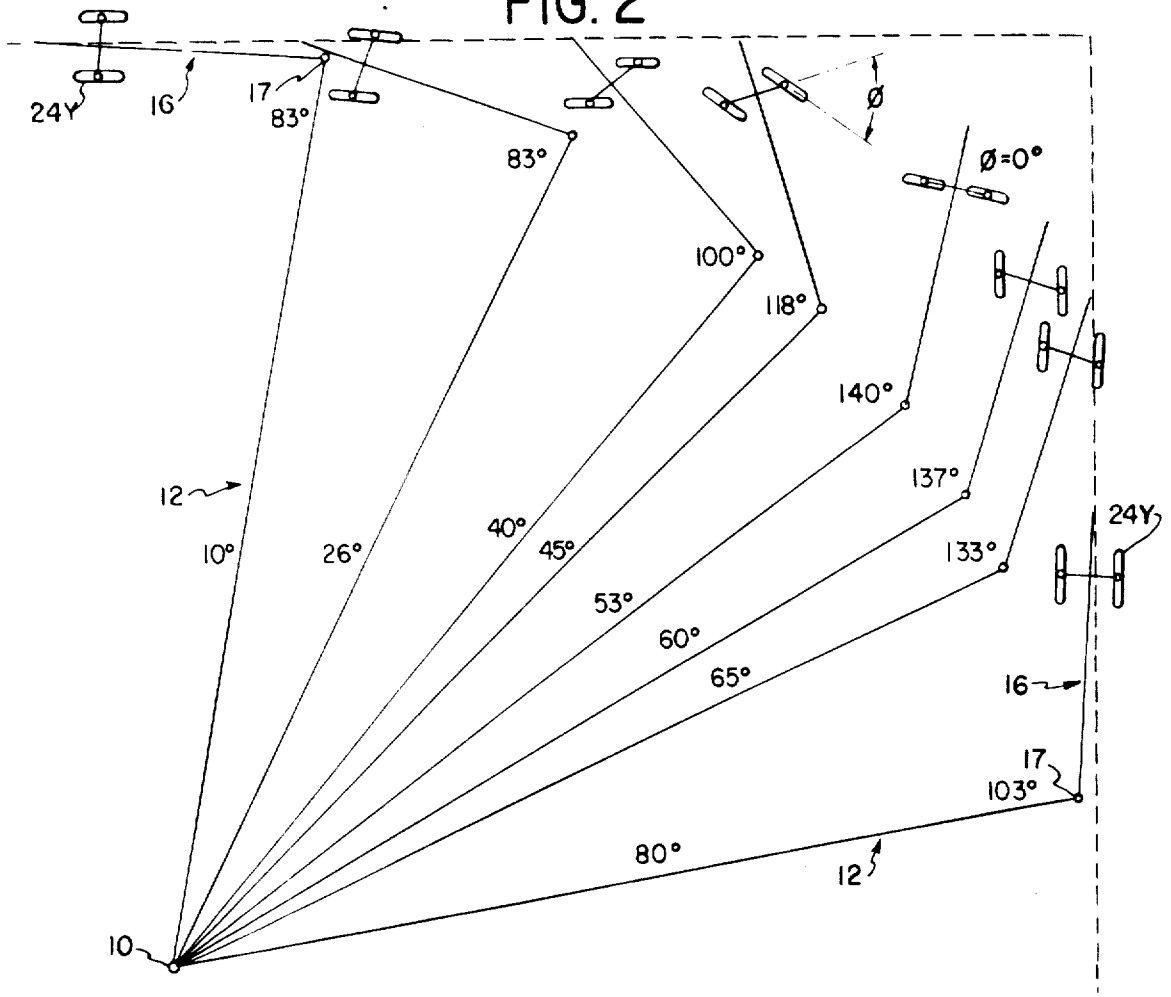

0°
26
22Y
24Y
16
16Y
22X
24X
16X
β
STRESS
SWITCH 29
17
18N
18B
12N
20B
18A
12
12B
α
12A
90°
10
MAIN ARM POSITION
31
POSITION
ANGLE
ENCODER
STEERING
WHEEL POSITION
32
COMP.
POSITION
ANGLE
ENCODER
30

FIG. 2


24Y
16
17
83°
83°
Ø
Ø=0°
100°
118°
140°
137°
133°
24Y
12
10°
26°
40°
45°
53°
60°
65°
16
17
103°
80°
12
10

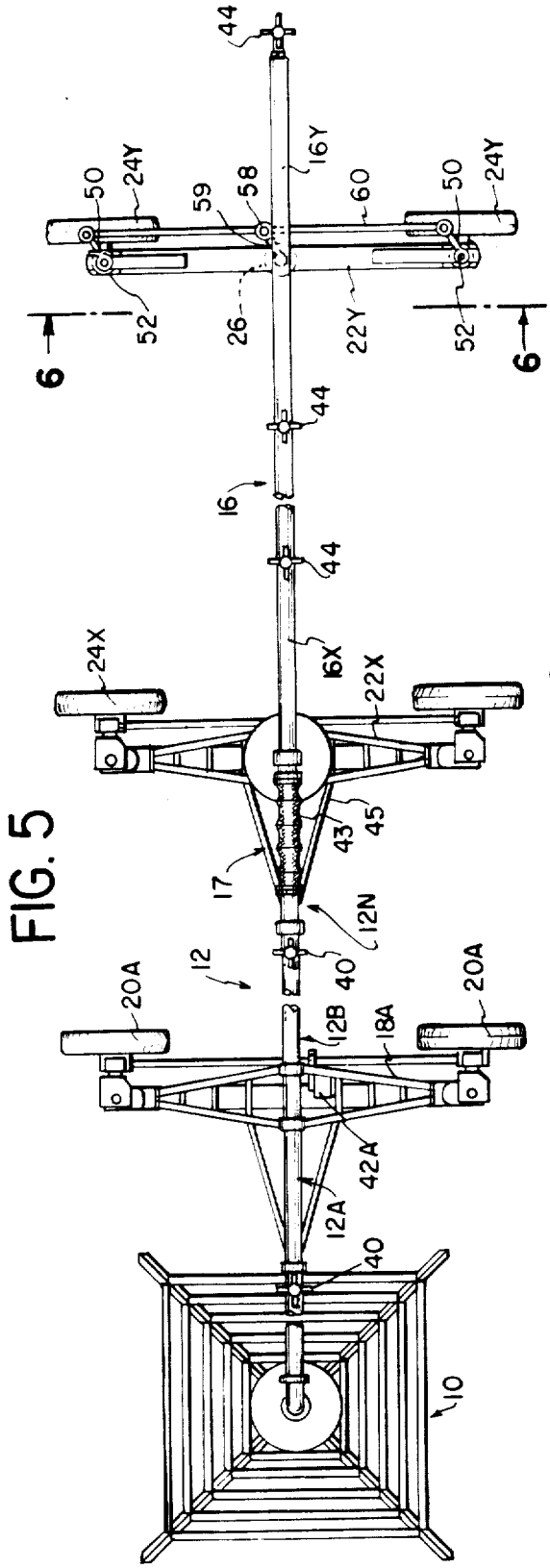


FIG. 5

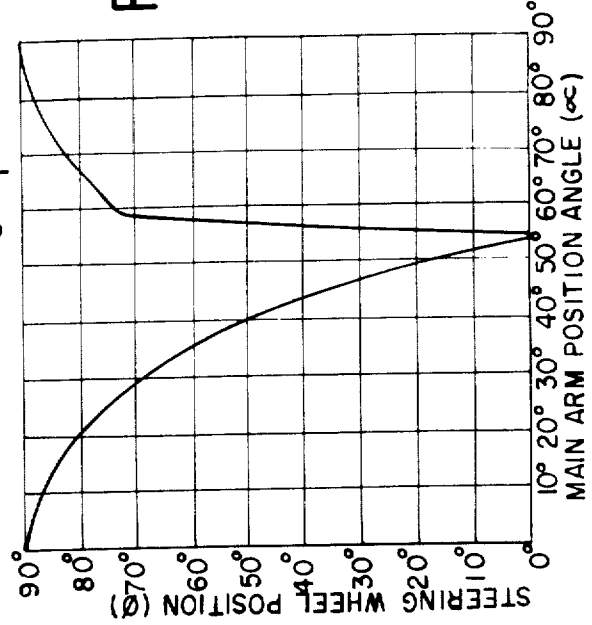


FIG. 3

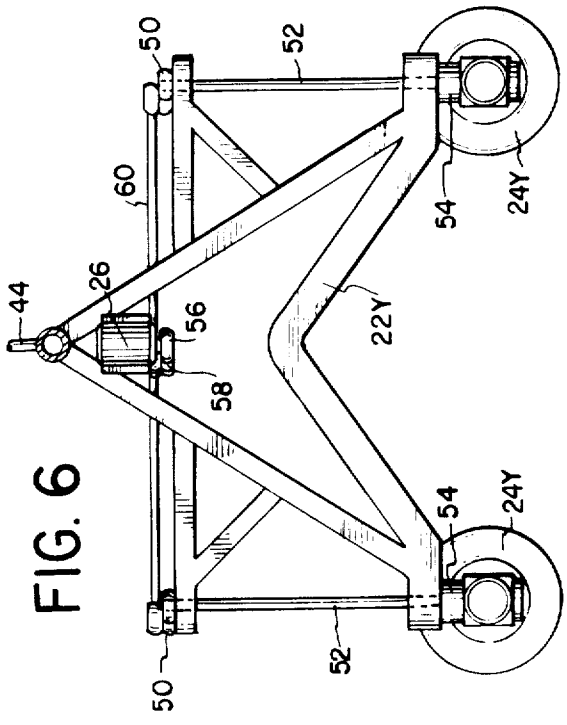


FIG. 6

FIG. 4A

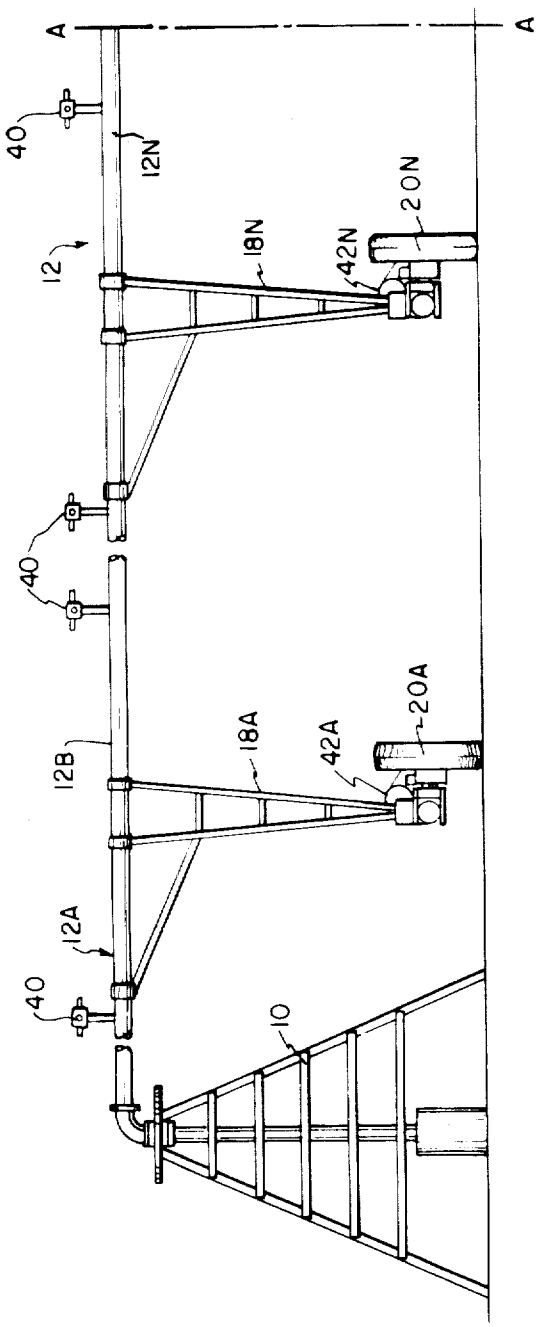

A
A
40
12N
18N
42N
20N
12
40
12B
18A
42A
20A
40
12A
40
10

FIG. 4B

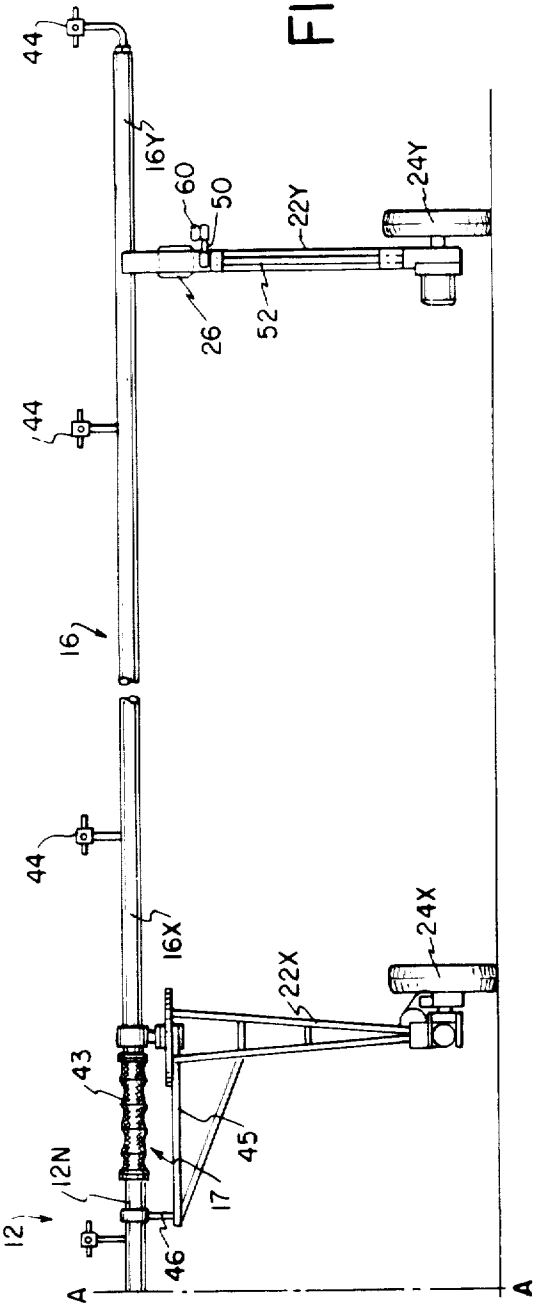
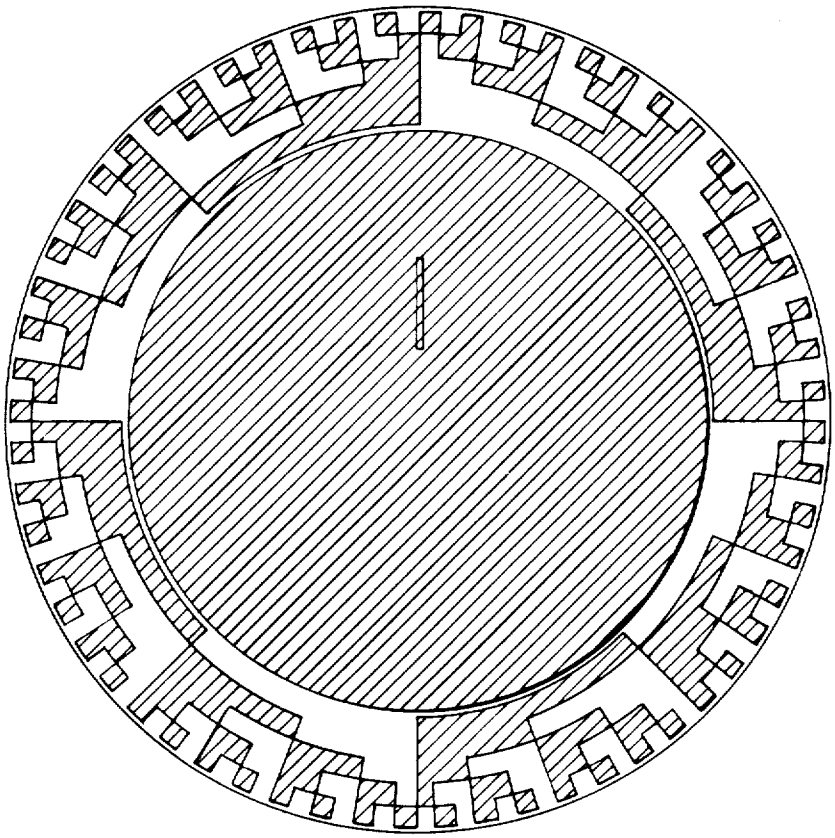

44
16Y
60
50
22Y
24Y
26
52
44
16
44
16X
22X
24X
43
45
12N
17
12
46
A
A

FIG. 7



IRRIGATION APPARATUS

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

This invention relates generally to irrigation apparatus, and, more particularly, to self-propelled irrigation apparatus of the center pivot type.

One popular manner of irrigating crops is through sprinkler irrigation. Of the various types of sprinkler apparatus, it has been found that the self-propelled, center pivot irrigation apparatus is the most effective type for irrigating large sections of land economically and in a uniform manner. Self-propelled irrigation apparatus of the center pivot type comprises an elongated main arm assembly, usually including several sections connected at their ends, supported at intervals by self-propelling wheeled support towers. The main arm assembly supports, or may itself constitute, a fluid carrying conduit and includes a large number of sprinklers or nozzles spaced along its length. One end of the assembly is pivotally coupled to a base and water supplied to the conduit is discharged from the sprinklers as the assembly rotates around the base, thereby uniformly irrigating a section of land.

One problem inherent in the use of such devices is that the irrigated section necessarily takes the form of a circle (with the arm as its radius). Thus, the use of center pivot type irrigation apparatus within a square section of land will result in a substantial portion of the land (outside the circle) remaining un-irrigated. It has been estimated that such systems fail to cover 21.4 percent of the potentially agriculturally productive area of a square field.

One method of attacking this problem has been to provide fluid discharge means, such as a water gun at the end of the arm assembly facing radially outwardly. Water is discharged through this gun when it faces the un-irrigated portions of the land. Such systems have not proved to be entirely adequate, however, since only a relatively narrow additional arc of land can be irrigated, and, moreover, these water-guns expel large droplets of water which can cause damage to delicate crops.

The present invention provides irrigating apparatus which is capable of irrigating sections of a field outside the circular area traversed by the main arm assembly of a center pivot irrigating apparatus. It avoids, or substantially minimizes, the drawbacks associated with known water-gun systems for accomplishing this objective, yet it is simple and relatively inexpensive. A particular advantage of the invention is that it may be readily incorporated into existing center pivot irrigation systems so that replacement of these costly systems is not required.

Briefly, in accordance with the invention, an extension arm is mounted at the free end of a main arm assembly which rotates about a center pivot. The extension arm carries sprinklers which irrigate areas outside of the circular area covered by the main arm assembly, and it is movable with respect to the main arm assembly to control the areas which it (the extension arm) covers. In the preferred embodiment of the invention, the extension arm pivots with respect to the main arm assembly and the position of the extension arm is controlled electrically as a function of the angular position of the main arm assembly.

The invention is described in detail below with reference to the annexed drawings, wherein:

FIG. **1** is a diagrammatic illustration of the preferred embodiment of the invention;

FIG. **2** shows diagrammatically the relative positions of the main arm assembly and extension arm for a representative scan of one quadrant of a field;

FIG. **3** is a graph showing steering wheel position as a function of the angle of the main arm assembly;

FIGS. **4A** and **4B** are front views of the main arm assembly and extension arm assembly, according to the invention;

FIG. **5** is a plan view of the main and extension arm assemblies;

FIG. **6** is a sectional view along the line **6—6** of FIG. **5**; and

FIG. **7** shows one of the encoding wheels used in the preferred embodiment.

The basic operation of this system according to the invention is explained with reference to FIG. **1**. The main arm assembly, shown generally at **12**, includes a plurality of separate sections **12A**, **12B**. . .**12N**, which are colinearly aligned. The extension arm is shown at **16** and, for example, may include two sections **16X** and **16Y**. The extension arm section **16X** is pivotally mounted at **17** to the outer or free extremity of the main arm section **12N**.

Each of the main arm sections **12A**, B. . .N is supported on a respective support tower **18A**, B. . .N, on which pairs of wheels **20A**, B. . .N are mounted. The extension arm sections **16X** and **16Y** are supported on towers **22X** and **22Y** which contain respective pairs of wheels **24X** and **24Y**. The constructions of the support towers **18** and **22** are identical except that the wheels **24X** and **24Y** are steerable. In practice, a single steering motor shown diagrammatically at **26** may be used to control the wheels **24Y** with the wheels **24X** being allowed to follow the wheels **24Y** either passively or with a power assist.

Water is supplied to the main arm assembly **12** and the extension arm assembly **16** both of which include sprinkler devices to distribute the water over the length of these arms. The main arm assembly may, for example, be 1,200 feet in length and require anywhere from 24 to 72 hours to rotate 360°.

Obviously, the main arm assembly **12**, which may be considered to be fixed in length, is only capable of covering a circular area of the field. The extension arm assembly **16**, when pivoted about point **17**, permits irrigation of a section of the field outside of this circular area. By controlling the position of the arm **16** with respect to the main arm **12** (represented by the angle β), it is possible to irrigate non-circular areas so that in many cases an entire field can be fully irrigated.

Conventionally, irrigating apparatus of the type disclosed is self-propelled in the sense that each pair of wheels **20A**, **20B**. . .N, is driven by a motor (not shown in FIG. **1**), for example, a constant speed electric motor. For purposes of explanation, the angular position of the main arm assembly **12** may be represented by the angle α (FIG. **1**). If it is desired to irrigate a square field, β should vary from 90° (at $\alpha=0°$) to its maximum when $\alpha=45°$ and back to 90° when $\alpha=90°$. This pattern repeats for each of the successive quadrants in the case of a square field. For purposes of mechanical stability, it is

generally desirable that the maximum value of β be less than 180°, for example, 140°.

There are a number of ways in which movement of the extension arm **16** may be controlled. In the preferred embodiments, as explained below, the position of the steering wheels is controlled electrically as a function of the position angle α of the main arm **12**.

As noted previously, the main [extension] arm consists of a series of sections **12A,B. . .N**, which are joined at flexible joints. In prior art constructions, where there is no extension, the driving motor for the outermost support tower **18N** is driven continuously. A microswitch is placed at the joint between the outermost section **12N** and the next adjacent section. When the microswitch is actuated because of stress at the joint caused by movement of the outermost section **12N**, the motor for this next section is actuated.

Similarly, movement of the second section actuates a microswitch at the junction of the second and third sections to operate the driving motor for the third section, and so forth for each of the remaining sections. Each of the motors drives its associated support wheels at the same rate of speed and, consequently, since the outermost section **12N** travels at the highest rate of speed, the inner sections would be operated intermittently with the innermost section operating over the shortest periods. The system is relatively simple and inexpensive since constant-speed motors, all of which are the same, can be used and special gear reduction units are not required for the individual sections.

According to the preferred embodiment of the invention, the system is controlled by movement of the extension arm rather than the outermost section of the main arm. The drive motor for tower **18N** is not continuously operated, but instead, is controlled by a stress switch shown diagrammatically at **29** in FIG. **1**.

In one embodiment of the invention, a position angle encoder **30** is located at the base **10** for the main [extension] arm **12**. The encoder **30** may be an analog-to-digital device which converts the angle α to a five-bit digital signal. A similar position angle encoder **31** is physically located at the support tower **22Y** for the steering wheels **24Y**, and also produces a five-bit digital signal representing the position angle of the steering wheels of the extension arm with respect to an arbitrarily selected reference angle (e.g. perpendicular to arm **16**).

The two digital signals from the encoders **30** and **31** are coupled to an electrical comparator **32** which produces an electrical control signal when the two digital signals are not equal (or have any other preselected relationship). This electrical signal is coupled to the steering motor **26** which causes the wheels **24Y** (and **24X**) to turn until the encoded digital output representing the steering wheel position is equal (or otherwise corresponds) to the output from the main arm position angle encoder **30**. At this position, the steering motor **26** is deactivated and the extension arm continues to rotate with the steering wheels in a fixed position.

As the extension arm **16** rotates, a position is reached where the stress on the *outermost section 12N of the* main [extension] arm [section **12N** cause] *causes* the stress switch **29** to be actuated. When switch **29** is actuated, it energizes the driving motor for the wheels on the *outermost section 12N of the* main [section **12N**] *arm* which then causes this section of the main [extension] arm to start moving. In a similar way, as described in the foregoing, the movement of this outer main section successively operates the drive motors associated with the remaining interior sections so that the main [extension] arm sweeps across the field.

In this embodiment, it is necessary to determine the direction in which the steering wheels must be aligned for each [discreet] *discrete* of the main arm assembly. This can be done mathematically if the lengths of the respective assemblies and their relative velocities are known. The direction of the extension arm steering wheels **24Y** for each [discreet] *discrete* (α) of the main arm is in the same direction as the velocity vector required for the outer point of the extension arm **16** relative to the base **10**. Hence, this velocity vector is computed for each [discreet] *discrete* position and then the encoder wheels (which produce a different digital signal for each main arm position) are properly positioned so as to cause the required control of the steering wheels. By way of example, FIG. **3** shows a workable relationship between the position angle α of the main arm and the steering wheel position angle ϕ as indicated in FIG. **2**.

It may appear from FIG. **3** that unusually abrupt changes in steering wheel position are required between $\alpha=40°$ and $\alpha=60°$ in view of the movement of the main arm assembly; however, the linear velocity of the outer section of the main arm **12** is very low, for example, in the order of 300 feet per hour. Therefore, for all intents and purposes, the turning of the steering wheels **22Y** may be considered to be instantaneous in the sense that the steering wheels are positioned very quickly with respect to the linear velocity of the assembly.

FIGS. **4A**, **4B**, **5** and **6**, show certain mechanical features of a system incorporating the invention. The parts illustrated in these figures have been numbered to correspond with FIG. **1**. Inasmuch as the construction of the main arm assembly is known, an extended discussion of the physical structure of the system is not included.

Sections, **12A,12B. . .N** of the main arm assembly are shown as consisting of hollow conduits through which water is applied to sprinklers **40** spaced along the individual sections. (Alternatively, a separate conduit for the water may be supported in conventional fashion on these sections). Drive motors **42A,42B. . .N** are mounted on respective support towers **18A,18B. . .N** to drive the wheels **20A,20B. . .N** which rotate the main arm assembly. As mentioned above, the manner in which these motors are controlled is standard, except that operation of motor **42N** is determined by the stress of the section **12N** caused by rotation of the extension arm **16**.

The outermost main arm section **12N** may be coupled to the inner extension arm section [**16A**] *16X* by a flexible hose **43** which will permit the required pivoting of extension arm **16** while supplying water to the extension arm sprinklers **44**. Support tower **22X** for the extension arm section **16X** may include a plate **45** in which a pin **46** extending downwardly from section **12N** is suitably journaled. Obviously, numerous other satisfactory arrangements can be used to provide the required pivotable movement between these two parts.

The steering arrangement for the steering wheels [**24B**] *24Y* is shown most clearly in FIGS. **5** and **6**. The steering motor **26** is physically supported on support tower **22Y** above the wheels. Motor **26** is a constant speed electrical motor which is turned on and off upon receipt of signals from comparator [**34**] *32* as described above with reference to FIG. **1**. The alignment or position of the steering wheels **22Y** is con-

trolled by a pin **50** connected to vertical connecting rods **52** which rotate axle supports **54** on which the wheels are mounted. The physical means for steering the wheels is conventional and, obviously, any suitable arrangement for steering wheels [22Y] *24Y* may be used.

As the assembly sweeps through any quadrant of the field, as explained above, it is necessary that the steering wheels be moved in first one direction so that the extension arm can start to move outwardly, and then back in the other direction so that the extension arm can return to its original position. *In other words, the extension arm assembly swings relative to the main arm assembly between a retracted position defined by an inward swing position of the extension arm assembly generally normal to the main arm assembly and an extended position defined by an outward swing position of the extension arm assembly.* Consequently, in practice, the steering wheels must be aligned in the same direction on two separate occasions during the sweep of any given quadrant (i.e., while "coming" and "going"). This creates a redundancy or ambiguity which ordinarily would require the electronic circuits of the comparator to measure the encoded position angle signals in such a way as to be able to determine the direction in which the extension arm is moving relative to the main arm.

According to a further feature of this embodiment, this requirement is avoided by a crank shaft type steering arrangement comprising a rotatable disc **56** which rotates in only one direction in response to the actuation of the steering motor **26**. The disc **56** is connected to the pins **50** by means of a link **58** suitably pinned to the edge of disc **56** (see FIG. **6**) at **59**, the other end of link **58** being connected to pins **50** by horizontal tie rods **60**. With this type of arrangement (and proper dimensioning and disposition of the steering mechanism), full rotation of disc **56** causes the steering wheel [22Y] *24Y* to rotate 90° in one direction (corresponding to rotation of disc **56** through 180°) and then back 90° to the starting position (as the disc **56** rotates from 180° to 360°). Consequently, since there is a [discreet] *discrete* position of disc **56** for each position of the main arm assembly throughout any given quadrant, there no longer exists the ambiguity referred to above, although the full steering cycle is still available.

A booster pump (not shown) may be associated with the extension arm **16**. The booster pump is desirable because the extension arm **16** moves at a higher velocity relative to ground than the main arm assembly **12**. To assure uniform irrigation, it may be desirable to provide more water to the sprinklers on the extension arm. The booster pump may be turned off when the extension arm is at right angles to the main arm ($\alpha=o$) and, if desired, may be operated to provide a variable water pressure at the extension arm sprinklers, depending upon the position of the extension arm. This control may be responsive to the encoded position angle signals in an obvious way. Control of the water pressure at the main arm sprinklers and/or sprinkler spacing may be pursuant to conventional practice.

FIG. **7** illustrates an encoding wheel which may be used in accordance with the preferred embodiment of the invention. The wheel illustrated in FIG. **7** may be read by photoelectric means, and suitable devices for this purpose are known. A similar wheel may be used as the steering wheel encoder with the physical disposition of the respective wheels being properly adjusted to cause a desired relationship between the extension arm **16** and the main arm **12** for each [discreet] *discrete* position of the main arm.

The encoding disc(s) or other encoding means may be modified as desired to alter the area covered by the combined main and extension arm assemblies. Similarly, although a preferred embodiment has been described, numerous other control systems could be used. For example, the control system may be responsive to a comparison of signals representing the position angles α and β. Other types of systems, such as hydraulic, may be used to control the movement of the extension arm.

What is claimed is:

1. Irrigating apparatus for supplying water to a non-circular area, comprising a rotatable main arm assembly *mounted at one end to a fixed base pivot and rotatable thereabout* for supplying water to a first portion of said area, an extension arm assembly at the *other* end of said main arm assembly for supplying water to portions of said area outside of said first portion, *said extension arm assembly and main arm assembly each being supported on one or more support towers, with each assembly supporting a plurality of spaced irrigating sprinklers, said main arm assembly support towers having wheels and wheel driving means,* means for moving said extension arm assembly with respect to said main arm assembly, and control means for operating said moving means to move said extension arm assembly relative to said main arm assembly to irrigate said portions outside of said first portion as said main arm rotates.

2. Apparatus according to claim **1**, wherein said moving means pivots said extension arm assembly relative to said main arm assembly.

3. Irrigating apparatus for supplying water to a non-circular area, comprising a rotatable main arm assembly for supplying water to a first portion of said area, an extension arm assembly pivotally mounted at the end of said main arm assembly for supplying water to portions of said area outside of said first portion, *said main arm assembly and said extension arm assembly each being supported on one or more support towers with each assembly including a plurality of spaced irrigating sprinklers,* means for *pivoting* said extension arm assembly relative to said main arm assembly, and control means for operating said [moving] means *for pivoting* in response to the angular position of the main arm assembly relative to said area.

4. Apparatus according to claim **3**, further including stress switch means located on said main arm assembly for initiating movement of said main arm assembly, said stress switch being actuated by stresses applied to said main arm assembly by movement of said extension arm assembly.

5. Apparatus according to claim **3**, wherein said main arm assembly includes a plurality of colinear sections, each of said sections including independent driving means, the driving means of the outermost section being responsive to the forces applied to the main arm assembly by movement of said extension arm assembly.

6. Apparatus according to claim **3**, wherein at least one of the support towers of said extension arm assembly *has* steerable wheels, and wherein said means *for pivoting* is adapted to steer said steerable wheels.

7. Irrigating apparatus according to claim **6**, wherein said control means includes a main arm position angle encoder for producing a mutli-bit digital signal representative of discreet positions of the main arm assembly, a steering wheel position encoder for producing a multi-bit digital signal representing the position of said steer-

ing wheel, and comparison means responsive to said multi-bit digital signals.

8. Irrigating apparatus for supplying water to a non-circular area, comprising a rotatable main arm assembly for supplying water to a first portion of said area, an extension arm assembly *pivotably* mounted at the free end of said main arm assembly for supplying water to portions of said area outside of said first portion, said main arm assembly and said extension arm assembly being supported on *support* towers having wheels *and wheel driving means*, at least one of the support towers for said extension arm assembly having steerable wheels, and steering means responsive to the angular position of the main arm assembly relative to said area for changing the direction of said steerable wheels to thereby *pivot* said extension arm assembly relative to said main arm assembly.

9. Apparatus according to claim 8, further including stress switch means located on said main arm assembly for initiating movement of said main arm assembly, said stress switch being actuated by stresses applied to said main arm assembly by movement of said extension arm assembly.

10. Apparatus according to claim 8, wherein said main arm assembly includes a plurality of colinear sections, each of said sections *being mounted on at least one support tower with the* driving means *for each section being independently operable*, the driving means of the outermost section being responsive to the forces applied to the main arm assembly by movement of said extension arm assembly.

11. Apparatus according to claim 8, wherein said steering means includes a member rotatable through 360°, and means coupling said member to said steering wheels with full rotation of said member turning said steering wheels a desired amount in one direction and then back that amount in the other direction.

12. Apparatus according to claim 8, wherein said steering means includes means for comparing said angular position of the main arm assembly to the position of said steerable wheels.

13. Apparatus according to claim 12, further including a main angle encoder for producing a digital signal representing the angular position of said main arm assembly and a steering wheel angle encoder for producing a digital signal representing the angular position of said steering wheels, said means for comparing being responsive to said digital signals.

14. Self-propelled irrigation apparatus of the center-pivot type comprising:

a main arm assembly pivotally coupled at a first end to a fixed base pivot;

an extension arm assembly pivotally coupled to the other end of the main arm assembly;

a fluid carrying conduit associated with the main and extension arm assemblies;

fluid discharge means spaced at intervals along the fluid carrying conduit *on both of said assemblies;*

a plurality of support towers having wheels and wheel driving means for supporting said main arm assembly and said extension arm assembly above the ground to be irrigated;

means for moving the extension arm assembly with respect to the main arm assembly; and

control means for operating said moving means to vary the angular position of the extension arm assembly relative to the main arm assembly as the main arm assembly rotates.

15. Apparatus according to claim 14, wherein the extension arm assembly is mounted on at least one support tower having steerable wheels.

16. [Apparatus as recited in claim 15, wherein the] *Self-propelled irrigation apparatus of the center-pivot type comprising:*

a main arm assembly pivotally coupled at a first end to a fixed base pivot;

an extension arm assembly pivotally coupled to the other end of the main arm assembly;

a fluid carrying conduit associated with the main and extension arm assemblies;

fluid discharge means apaced at intervals along the fluid carrying conduit on both of said assemblies;

a plurality of support towers for supporting said main arm assembly and said extension arm assembly above the ground to be irrigated;

at least one support tower for the extension arm assembly having steerable wheels;

means for moving the extension arm assembly with respect to the main arm assembly; and control means [includes], *including* means responsive to the angular position of the main arm assembly with respect to the area being [irrigated] *irrigated, for operating said moving means to vary the angular position of the extension arm assembly relative to the main arm assembly as the main arm assembly rotates.*

17. For use with a center-pivot irrigation apparatus which includes a main arm assembly mounted at a first end to a fixed base pivot and rotatable therearound, the main arm assembly including a fluid carrying conduit having fluid discharge means spaced at intervals there[along,] *along and being supported on one or more support towers having wheels and wheel driving means,* the improvement comprising:

an extension arm assembly pivotally mounted to the other end of the main arm assembly for supporting a fluid carrying conduit *and a plurality of spaced fluid discharge means;*

at least one support tower for supporting said extension arm assembly above the ground to be irrigated;

means for moving the extension arm assembly with respect to the main arm assembly, and

control means for operating said moving means to vary the angular position of the extension arm assembly relative to the main arm assembly as the main arm assembly rotates.

18. [The improvement of claim 17, wherein] *For use with a center-pivot irrigation apparatus which includes a main arm assembly mounted at a first end to a fixed base pivot and rotatable therearound, the main arm assembly including a fluid carrying conduit having fluid discharge means spaced at intervals therealong, the improvement comprising:*

an extension arm assembly pivotally mounted to the other end of the main arm assembly for supporting a fluid carrying conduit and a plurality of spaced fluid discharge means;

at least one support tower for supporting said extension arm assembly above the ground to be irrigated;

each support tower for the extension arm assembly including steerable wheels;

means for moving the extension arm assembly with respect to the main arm assembly including means for steering and driving said wheels responsive to the angular position of the main arm assembly relative to the area being [irrigated] *irrigated; and*

control means for operating said moving means to vary the angular position of the extension arm assembly relative to the main arm assembly as the main arm assembly rotates.

19. [The improvement of claim 17, wherein said] *For use with a center-pivot irrigation apparatus which includes a main arm assembly mounted at a first end to a fixed base pivot and rotatable therearound, the main arm assembly including a fluid carrying conduit having fluid discharge means spaced at intervals therealong, the improvement comprising:*

an extension arm assembly pivotally mounted to the other end of the main arm assembly for supporting a fluid carrying conduit and a plurality of spaced fluid discharge means;

at least one support tower for supporting said extension arm assembly above the ground to be irrigated;

means for moving the extension arm assembly with respect to the main arm assembly; and

control means [is] responsive to the position of the main arm assembly relative to said [area.] *area for operating said moving means to vary the angular position of the extension arm assembly relative to the main arm assembly as the main arm assembly rotates.*

20. The improvement according to claim 17, wherein said moving means pivots said extension arm assembly first in one direction and then in the other, with the maximum angle between the main arm assembly and the extension arm assembly being less than 180°.

21. The irrigating apparatus of claim 17 wherein each support tower for the extension arm assembly includes steerable wheels and said moving means includes means for steering and driving said steerable wheels.

22. Irrigating apparatus for supplying water to a non-circular area, comprising a rotatable main arm assembly mounted at a first end to a fixed base pivot and rotatable therearound for supplying water to a first portion of said area, an extension arm assembly connected at the other end of said main arm assembly for swinging movement of said extension arm assembly relative to said main arm assembly for supplying water to portions of said area outside of said first portion, said extension arm assembly and main arm assembly each having a fluid carrying conduit associated therewith, the fluid carrying conduit of said main arm assembly comprising a series of conduit sections connected end to end, each assembly being supported on one or more support towers having wheels and wheel driving means, at least one of the support towers for said extension arm assembly having steerable wheels, with each assembly supporting a plurality of spaced irrigating sprinkler, means for moving said extension arm assembly with respect to said main arm assembly, said moving means including means for driving and steering said steerable wheels, and control means for operating said moving means to move said extension arm assembly between a retracted position defined by an inward swing position of the extension arm assembly and an extended position defined by an outward swing position of the extension arm assembly relative to said main arm assembly to irrigate said portions outside of said first portion as said main arm rotates.

23. The irrigating apparatus of claim 22 wherein each support tower for the extension arm assembly includes steerable wheels.

24. The irrigating apparatus of claim 22 wherein each main arm conduit section is supported on at least one support tower with the driving means for each section being independently operable.

25. Irrigating apparatus for supplying water to a non-circular area, comprising a rotatable main arm assembly mounted at a first end to a fixed base pivot and rotatable therearound for supplying water to a first portion of said area, an extension arm assembly at the other end of said main arm assembly for supplying water to portions of said area outside of said first portion, said extension arm assembly and main arm assembly each being supported on one or more support towers having wheels and wheel driving means, at least one of the support towers for the extension arm assembly having steerable wheels, with each assembly supporting a plurality of spaced irrigating sprinklers, means for moving said extension arm assembly with respect to said main arm assembly, said moving means including means for steering said steerable wheels, and control means operatively connected to said steering means, thereby operating said moving means, to move said extension arm assembly relative to said main arm assembly to irrigate said portions outside of said first portion as said main arm rotates.

26. Irrigating apparatus for supplying water to a non-circular area, comprising a rotatable main arm assembly for supplying water to a first portion of said area, the main arm assembly having a fluid carrying conduit associated therewith defined by a series of conduit sections connected end to end and further including means to maintain said main arm conduit sections substantially in a predetermined alignment as said main arm assembly rotates, an extension arm assembly at the end of said main arm assembly for supplying water to portions of said area outside of said first portion, said extension arm assembly and main arm assembly each being supported on one or more support towers, said main arm assembly support towers having wheels and wheel driving means, at least one of the support towers for said extension arm assembly having steerable wheels, with each assembly supporting a plurality of spaced irrigating sprinklers, means for moving said extension arm assembly with respect to said main arm assembly, said moving means including means for driving and steering said steerable wheels, and control means for operating said moving means to move said extension arm assembly relative to said main arm assembly to irrigate said portions outside of said first portion as said main arm rotates.

27. The irrigating apparatus of claim 26 wherein said moving means causes said extension arm to swing relative to said main arm.

28. The irrigating apparatus of claim 26 wherein each support tower for the extension arm assembly includes steerable wheels.

29. Irrigating apparatus for supplying water to a non-circular area, comprising a rotatable main arm assembly mounted at a first end to a fixed base pivot and rotatable therearound for supplying water to a first portion of said area, an extension arm assembly connected at the other end of said main arm assembly for swinging movement of said extension arm assembly relative to said main arm assembly for supplying water to portions of said area outside of said first portion, said extension arm assembly and main arm assembly each being supported on one or more support towers, said main arm assembly support towers having wheels and wheel driving means, with each assembly supporting a plurality of spaced irrigating sprinklers, means for moving said extension arm assembly with respect to said main arm assembly, and control means for operating said moving means to move said extension arm assembly between a retracted position defined by an inward swing position of the extension arm assembly and an extended position defined by an outward swing position of the exten-

sion arm assembly relative to said main arm assembly to irrigate said portions outside of said first portion as said main arm rotates.

30. The irrigating apparatus of claim 29 wherein said extension arm assembly swings relative to said main arm assembly from a retracted position generally normal to the main arm assembly, out to an extended position with the extension arm assembly swung outwardly from its retracted position, and then back to a retracted position generally normal to said main arm assembly, as said irrigating apparatus moves through a non-circular area.

31. The irrigating apparatus of claim 29 wherein at least one of the support towers for said extension arm assembly has steerable wheels, and said moving means includes means for steering said wheels.

32. The irrigating apparatus of claim 29 wherein at least one of the support towers for said extension arm assembly has steerable wheels and wheel driving means, and wherein the control means controls the steerable wheels of said extension arm assembly.

33. Irrigating apparatus for supplying water to a non-circular area, comprising a rotatable main arm assembly mounted at a first end to a fixed base pivot and rotatable therearound for supplying water to a first portion of said area, an extension arm assembly at the other end of said main arm assembly for supplying water to portions of said area outside of said first portion, said extension arm assembly and main arm assembly each being supported on one or more support towers, said main arm support towers having wheels and wheel driving means, at least one of the support towers for said extension arm assembly having steerable wheels, with each assembly supporting a plurality of spaced irrigating sprinklers, means for moving said extension arm assembly with respect to said main arm assembly, and control means for operating said moving means to move said extension arm assembly relative to said main arm assembly to irrigate said portions outside of said first portion as said main arm rotates.

34. Irrigating apparatus for supplying water to a non-circular area, comprising a rotatable main arm assembly mounted at a first end to a fixed base pivot and rotatable therearound for supplying water to a first portion of said area, an extension arm assembly at the other end of said main arm assembly for supplying water to portions of said area outside of said first portion, said extension arm assembly and main arm assembly each being supported on one or more support towers having wheels and wheel driving means, with each assembly supporting a plurality of spaced irrigating sprinklers, steering means for moving said extension arm assembly with respect to said main arm assembly, and control means for operating said steering means to move said extension arm assembly relative to said main arm assembly to irrigate said portions outside of said first portion as said main arm rotates.

35. Irrigating apparatus for supplying water to a non-circular area, comprising a rotatable main arm assembly mounted at a first end to a fixed base pivot and rotatable therearound for supplying water to a first portion of said area, an extension arm assembly connected at the other end of said main arm assembly for swinging movement of said extension arm assembly relative to said main arm assembly for supplying water to portions of said area outside of said first portion, said extension arm assembly and main arm assembly each having a fluid carrying conduit associated therewith, the fluid carrying conduit of said main arm assembly comprising a series of conduit sections connected end to end, each assembly being supported on a plurality of support towers having wheels and wheel driving means, at least two of the support towers for said extension arm assembly having steerable wheels, with each assembly supporting a plurality of spaced irrigating sprinklers, means for moving said extension arm assembly with respect to said main arm assembly, said moving means including means for driving and steering said steerable wheels, and control means for operating said moving means to move said extension arm assembly between a retracted position defined by an inward swing position of the extension arm assembly and an extended position defined by an outward swing position of the extension arm assembly relative to said main arm assembly to irrigate said portions outside of said first portion as said main arm rotates.

36. For use with an irrigating apparatus for supplying water to a noncircular area which includes a rotatable main arm assembly for supplying water to a first portion of said area, the main arm assembly having a fluid carrying conduit associated therewith defined by a series of conduit sections connected end to end, the main arm assembly being supported on one or more support towers having wheels and wheel driving means and supporting a plurality of spaced irrigating sprinklers, said main arm further including means to maintain said main arm conduit sections substantially in a predetermined alignment as said main arm assembly rotates, the improvement comprising:

an extension arm assembly connected at the end of said main arm assembly for swinging movement of said extension arm assembly relative to said main arm assembly for supplying water to portions of said area outside of said first portion, said extension arm assembly having a fluid carrying conduit associated therewith and being supported on one or more support towers having wheels and wheel driving means, at least one of the support towers for said extension arm assembly having steerable wheels, said extension arm assembly supporting a plurality of spaced irrigating sprinklers;

means for moving said extension arm assembly with respect to said main arm assembly, said moving means including means for driving and steering said steerable wheels;

and control means for operating said moving means to move said extension arm assembly between a retracted position defined by an inward swing position of the extension arm assembly and an extended position defined by an outward swing position of the extension arm assembly relative to said main arm assembly to irrigate said portions outside of said first portion as said main arm rotates.

37. For use with a center-pivot irrigating apparatus for supplying water to a noncircular area which includes a rotatable main arm assembly for supplying water to a first portion of said area, the main arm assembly being mounted at a first end to a fixed base pivot and rotatable therearound, the main arm assembly being supported on one or more support towers having wheels and wheel driving means and supporting a plurality of spaced irrigating sprinklers, the improvement comprising:

an extension arm assembly at the end of said main arm assembly for supplying water to portions of said area outside of said first portion, said extension arm assembly being supported on one or more support towers at least one of the support towers for the extension arm assembly having steerable wheels, the extension arm assembly supporting a plurality of spaced irrigating sprinklers;

means for moving said extension arm assembly with respect to said main arm assembly, said moving

means including means for steering said steerable wheels;

and control means operatively connected to said steering means, thereby operating said moving means, to move said extension arm assembly relative to said main arm assembly to irrigate said portions outside of said first portion as said main arm rotates.

38. For use with a center-pivot irrigating apparatus for supplying water to a noncircular area which includes a rotatable main arm assembly for supplying water to a first portion of said area, the main arm assembly being mounted at a first end to a fixed base pivot and rotatable therearound, said main arm assembly being supported on one or more support towers having wheels and wheel driving means and supporting a plurality of spaced irrigating sprinklers, the improvement comprising:

an extension arm assembly at the other end of said main arm assembly for supplying water to portions of said area outside of said first portion, said extension arm assembly being supported on one or more support towers at least one of the support towers for the extension arm assembly having steerable wheels, said extension arm assembly supporting a plurality of spaced irrigating sprinklers;

means for moving said extension arm assembly with respect to said main arm assembly including means for driving said steerable wheels;

and control means for operating said moving means to move said extension arm assembly relative to said main arm assembly to irrigate said portions outside of said first portion as said main arm rotates.

39. For use with a center-pivot irrigating apparatus for supplying water to a noncircular area which includes a rotatable main arm assembly for supplying water to a first portion of said area, the main arm assembly being mounted at a first end to a fixed base pivot and rotatable therearound and having a fluid carrying conduit associated therewith, the fluid carrying conduit of said main arm assembly comprising a series of conduit sections connected end to end, the main arm assembly being supported on a plurality of self-propelled support towers, said main arm assembly having means to maintain said main arm conduit sections substantially in a predetermined alignment as said main arm assembly rotates, the main arm assembly supporting a plurality of spaced irrigating sprinklers, the improvement comprising:

an extension arm assembly connected at the other end of said main arm assembly for swinging movement of said extension arm assembly relative to said main arm assembly for supplying water to portions of said area outside of said first portion, said extension arm assembly having a fluid carrying conduit associated therewith and being supported on at least one self-propelled support tower having steerable wheels, said extension arm assembly supporting a plurality of spaced irrigating sprinklers;

means for moving said extension arm assembly with respect to said main arm assembly, said moving means including means for driving and steering said steerable wheels;

and control means for operating said moving means to move said extension arm assembly between a retracted position defined by an inward swing position of the extension arm assembly and an extended position defined by an outward swing position of the extension arm assembly relative to said main arm assembly to irrigate said portions outside of said first portion as said main arm rotates.

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