United States Patent

[11] 3,623,666

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[54] **SPRINKLER HEAD**
6 Claims, 13 Drawing Figs.

[52] **U.S. Cl.** **239/230,** 239/233
[51] **Int. Cl.** **B05b 3/08**
[50] **Field of Search** 239/230, 233

[56] **References Cited**

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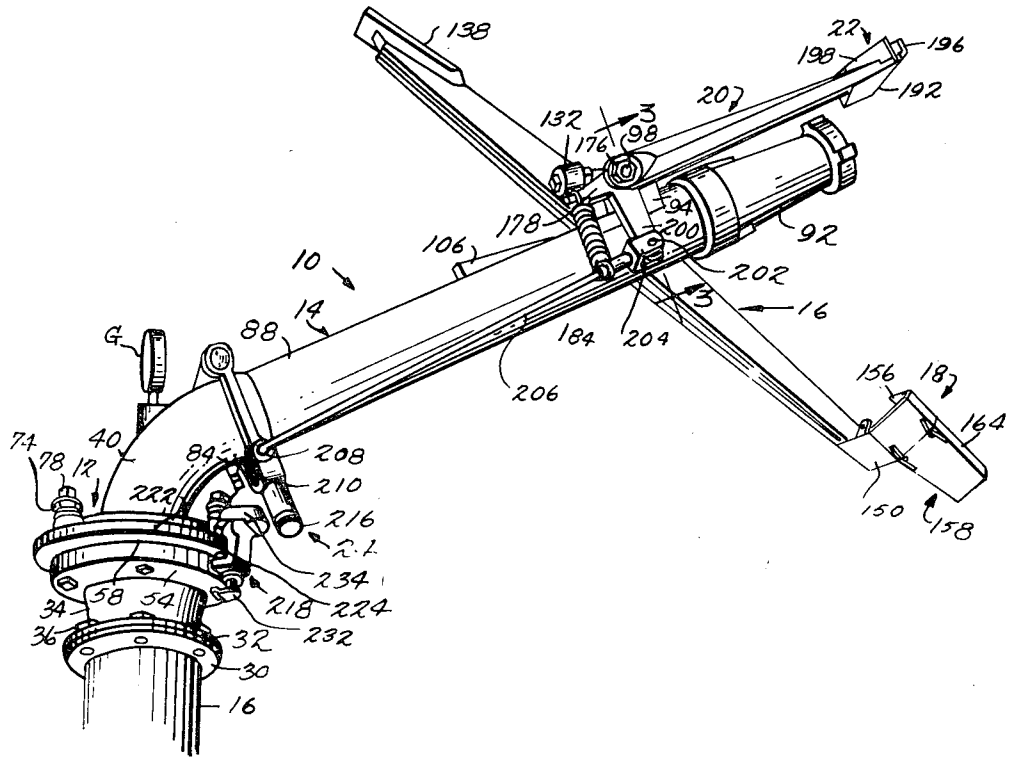
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Primary Examiner—Lloyd L. King
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ABSTRACT: A high capacity agricultural irrigation sprinkler head of the type which is rotated in step-by-step fashion by an oscillating impulse arm having a reactant element providing a stream engaging reactant surface area for effecting both the oscillating movement of the impulse arm and the incremental rotational movements of the sprinkler body, the reactant element is mounted on the impulse arm for resiliently biased pivotal movement to automatically compensate for changes in water pressure and nozzle outlet size through a wide range to produce a generally constant oscillatory arm speed and a generally constant intermittent rotational speed by varying the angle of deflection or angle of divergence of the stream in response to variation in the energy of the stream engaged thereby. The sprinkler head also includes a reversing arm having a reactant element which is moved into and out of the stream by an over-riding cam mechanism, the reactant element being normally biased out of the stream and retained in the stream when initially moved therein by the cam mechanism solely by the action of the stream thereon against its normal bias, the reactant element of the reversing arm including a portion providing a reactant surface area for effecting the reversing movement which is similarly mounted on the reversing arm for resiliently biased pivotal movement to likewise automatically compensate for changes in water pressure and nozzle outlet size to produce a generally constant reversing speed by varying the angle of deflection of the stream in response to variation in the energy of the stream.



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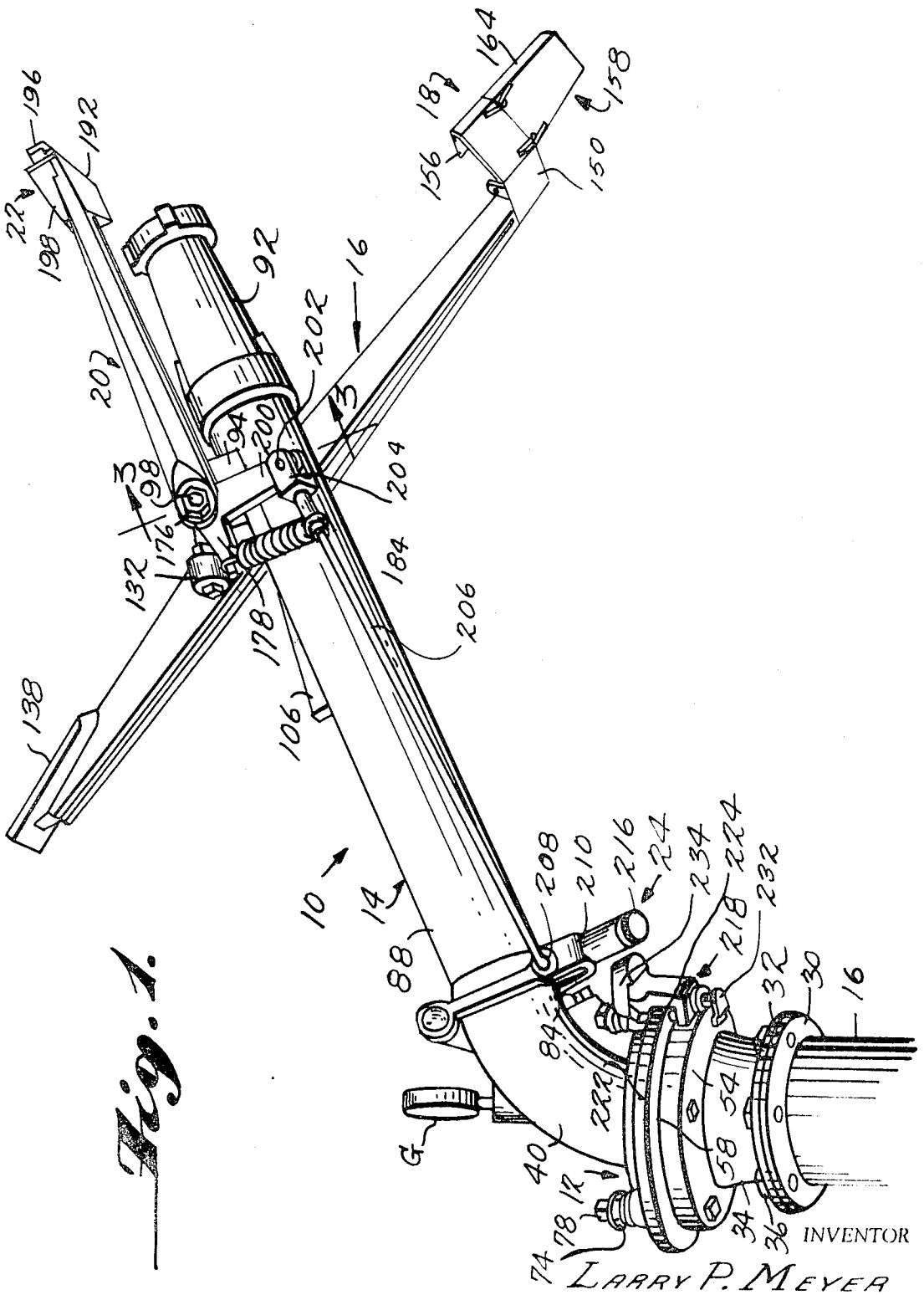
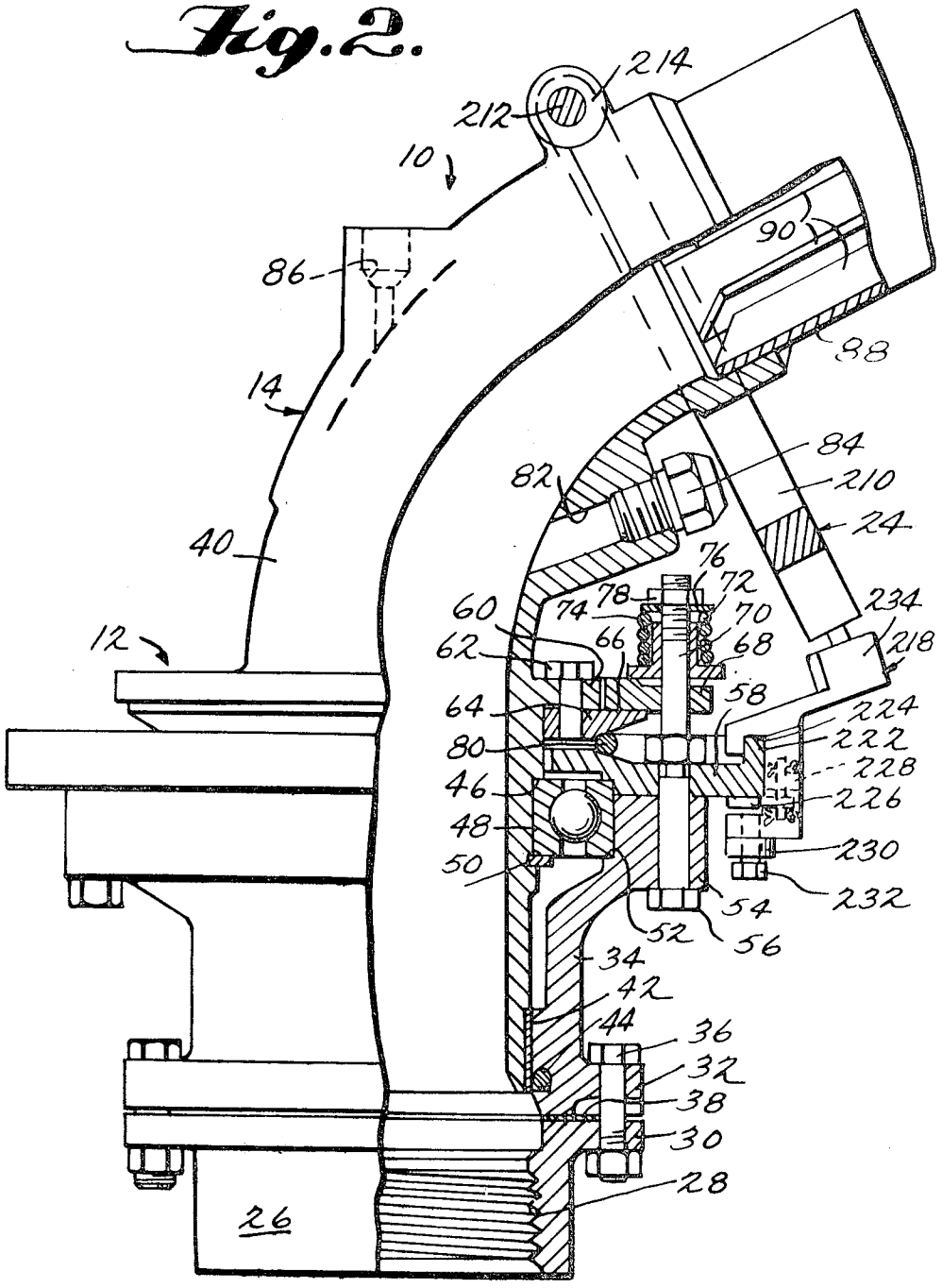


Fig. 1.

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Fig. 2.



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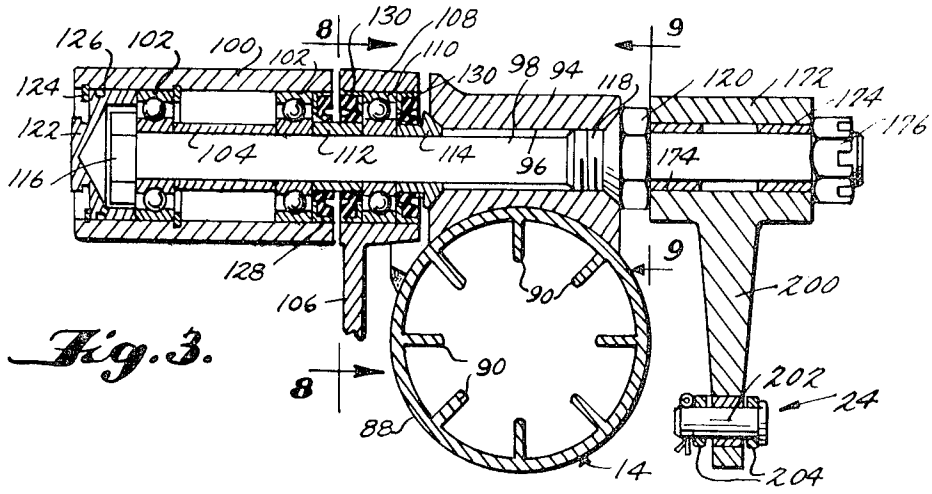
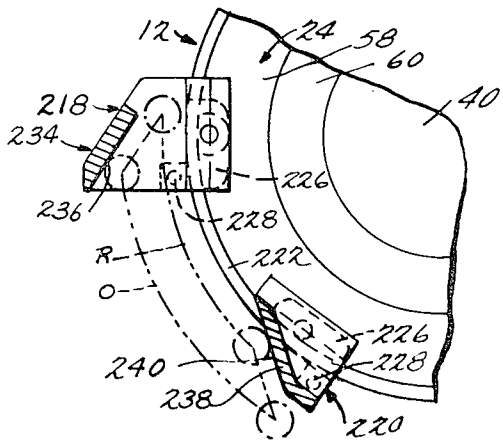


Fig. 3.

Fig. 13.



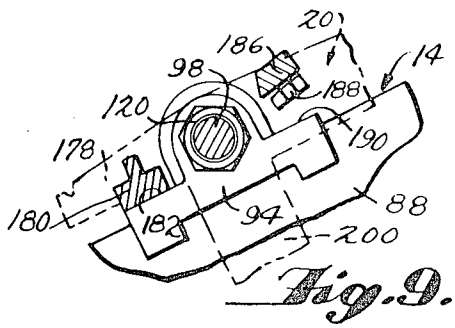


Fig. 9.

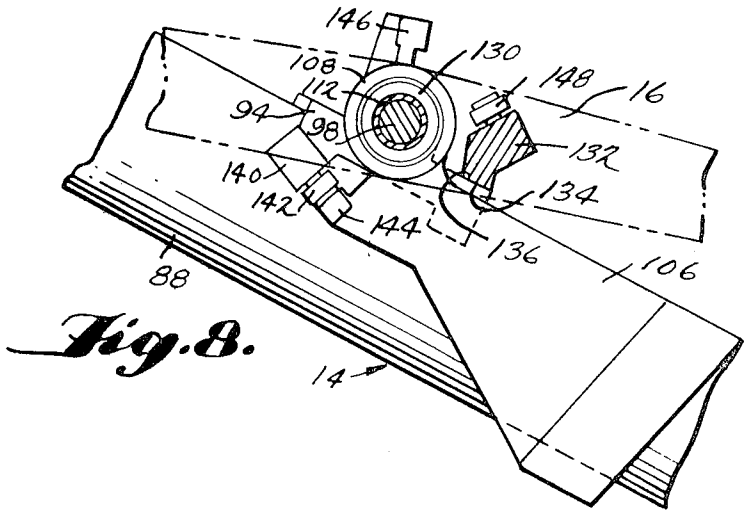


Fig. 8.

Fig. 6.

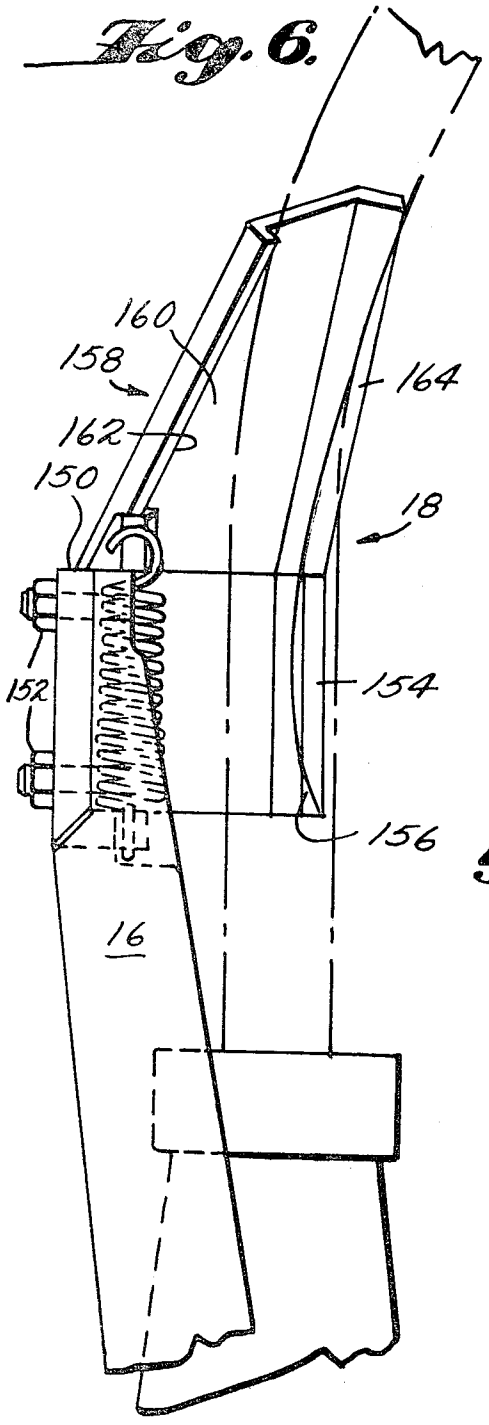
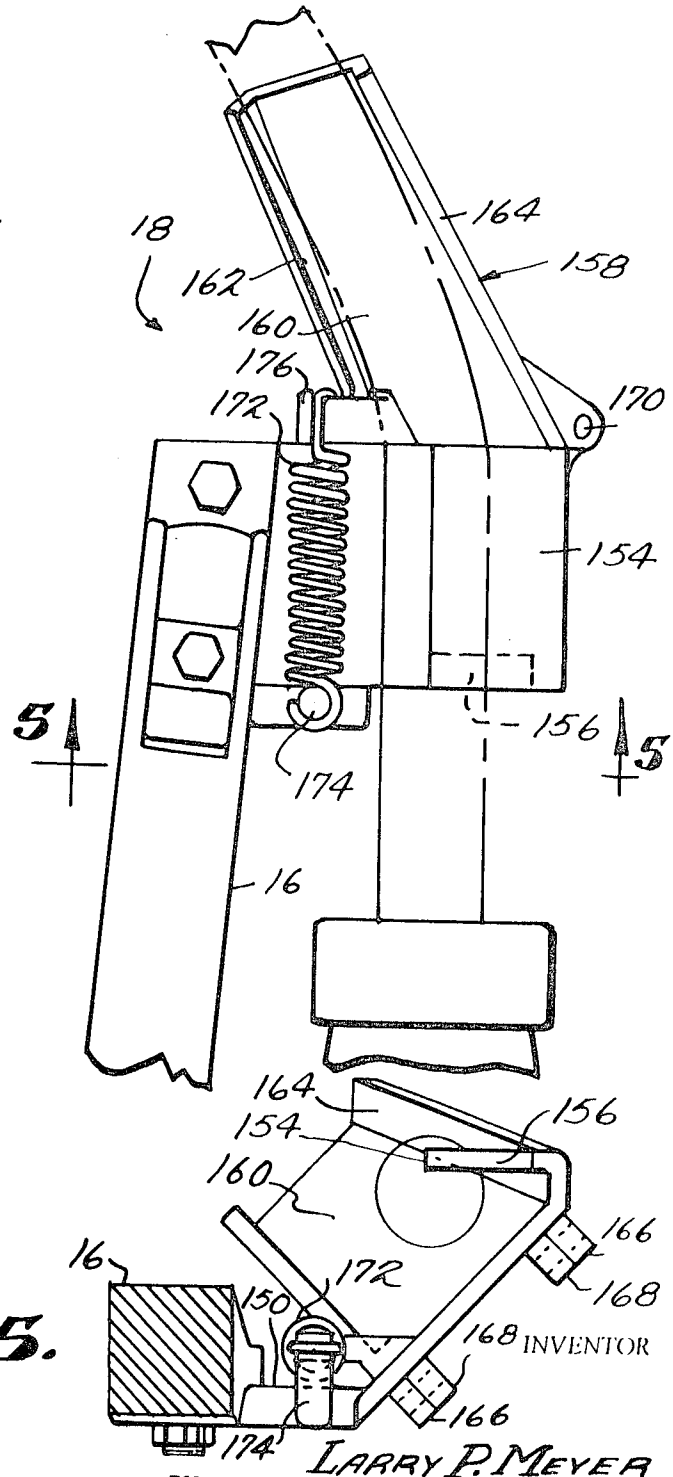


Fig. 5.

Fig. 4.



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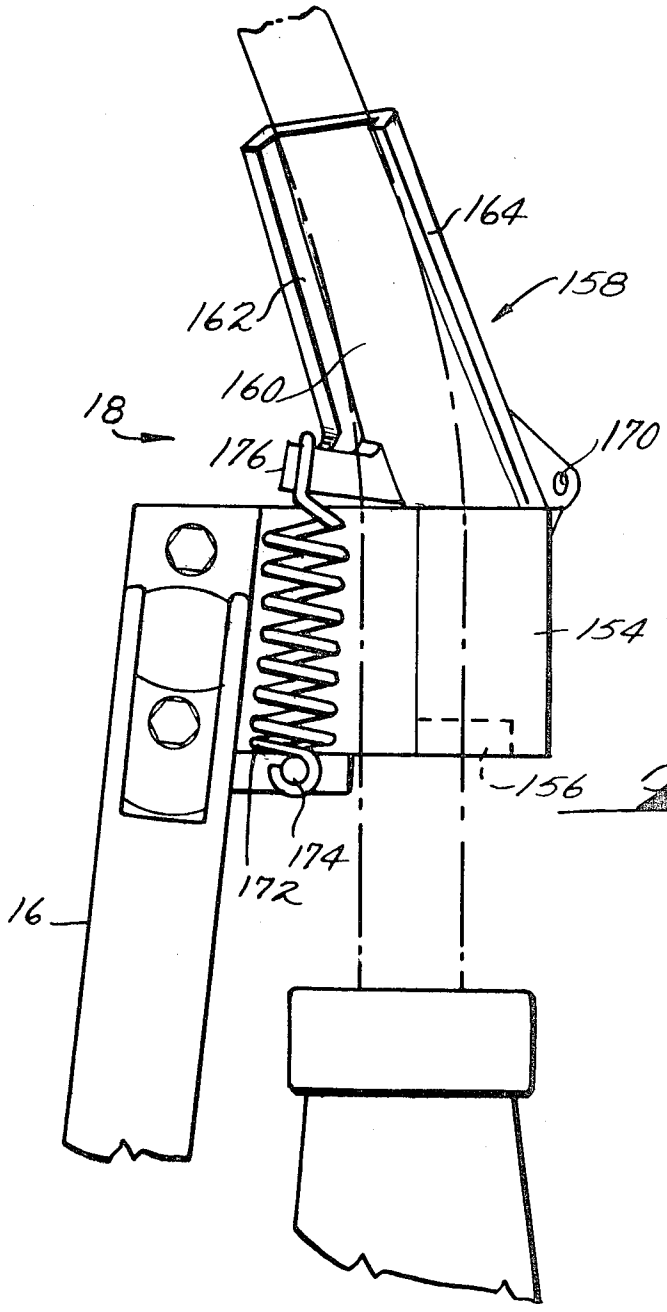


Fig. 7.

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Fig. 10.

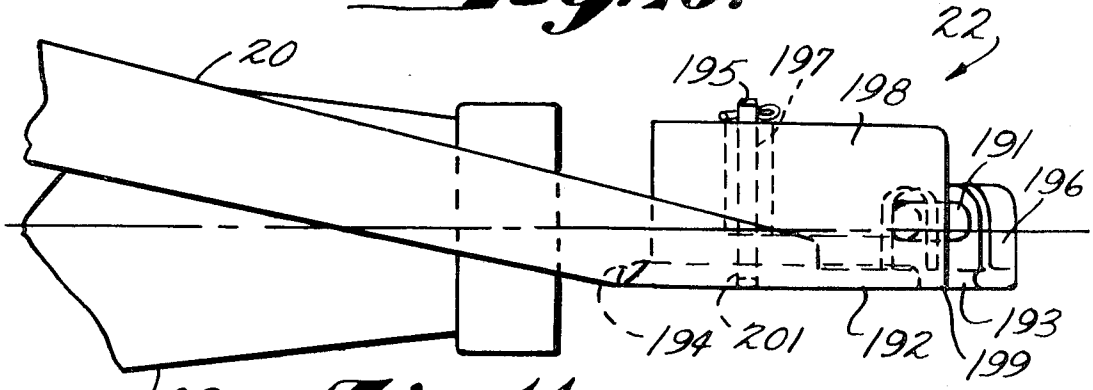


Fig. 11.

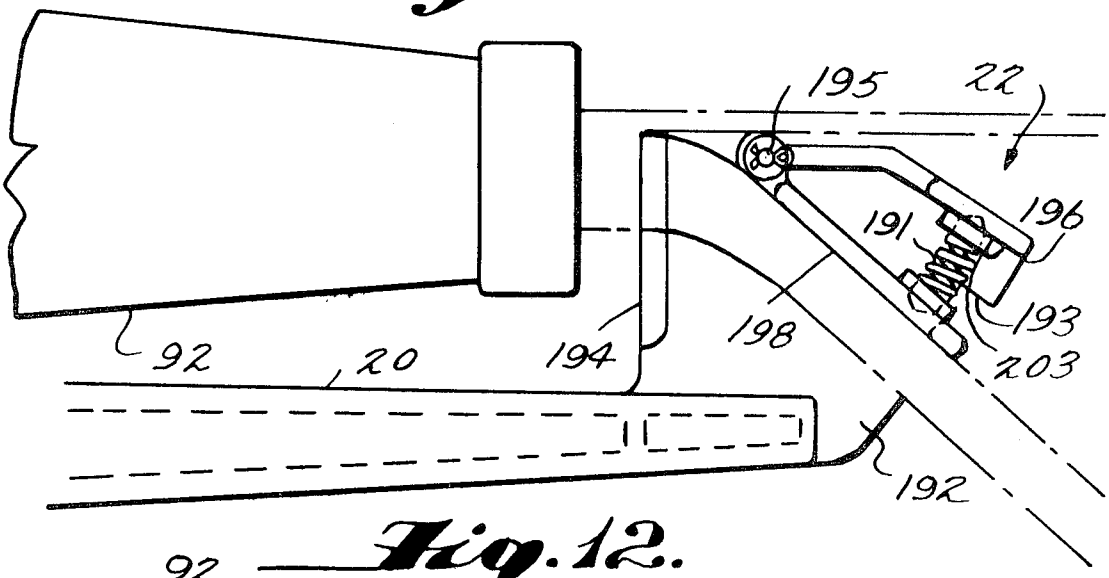
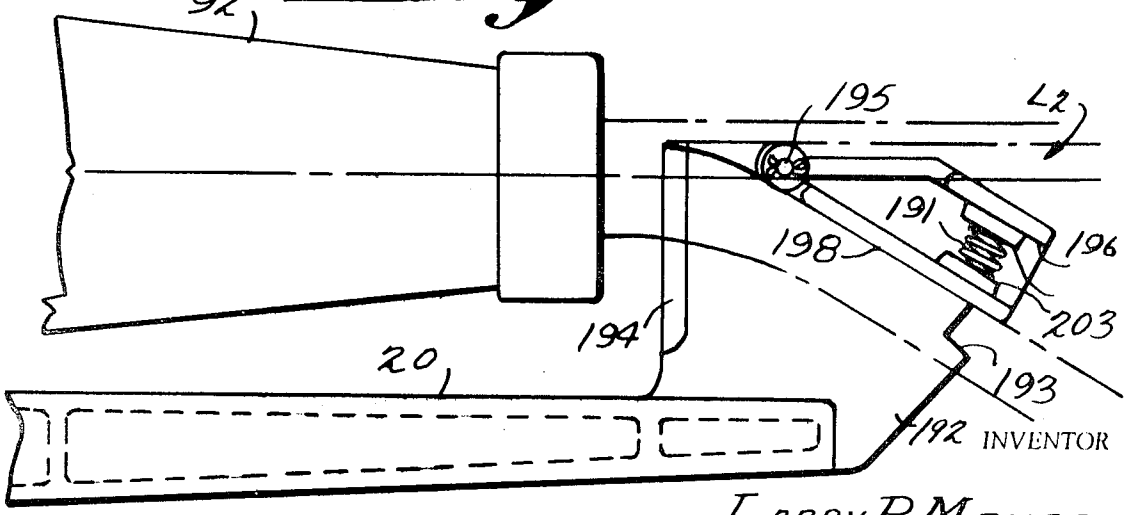


Fig. 12.



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SPRINKLER HEAD

This invention relates to sprinkler heads and more particularly to high capacity sprinkler heads of the type used in agricultural irrigation sprinkling.

High capacity sprinkler heads have increased in use with the increase in agricultural sprinkler irrigation. High capacity sprinkler heads of the type to which the present invention relates are adapted to operate in a range of approximately 290 to 1,025 g.p.m. and to cover an area having a diameter of from 370 feet to 590 feet.

Such high capacity sprinkler heads are contrasted with the more common low capacity sprinkler heads which find use in agricultural sprinkler irrigation as well as lawn and athletic field maintenance. Low capacity sprinklers are adapted to operate within a range of something less than one g.p.m. up to about 35 or 40 g.p.m. for lawn and athletic field and in the range of 38 g.p.m. to 125 g.p.m. covering a diameter of 170 to 235 feet.

While both high capacity and low capacity sprinkler heads are operable to cover the area to be sprinkled with a step-by-step rotary movement, the manner in which the step-by-step movement is accomplished differs. Most low capacity step-by-step rotary sprinklers embody an impulse arm which is mounted for oscillatory movement about an axis coincident with the rotational axis of the sprinkler head body. The incremental rotational movement of the sprinkler body is accomplished by the force of the impulse arm striking a portion of the sprinkler body at the end of the return stroke of the impulse arm. While most high capacity sprinkler heads embody an oscillating impulse arm, in general, the impulse arm doe not effect the incremental rotational movement of the sprinkler body by striking a portion of the same at the end of its return stroke, as is the case with the low capacity sprinklers.

One type of prior art high capacity sprinkler head achieves incremental rotation of the sprinkler body by a reaction force applied by the stream to a reactant element carried by the impulse arm. An example of a device of this type is illustrated in U.S. Pat. No. 2,649,268.

Since high capacity sprinkler heads are efficiently used primarily in agricultural irrigation and are not suitable to the lawn and athletic field mass market, they must be produced on a limited basis as compared with low capacity sprinkler heads. Moreover, because of their greater capacity and the greater operating water pressures involved, they must be of much sturdier construction. Due to this situation, it is not practical to manufacture a variety of different size high capacity sprinkler heads to accommodate different portions in the overall range of use as is the case with low capacity sprinklers. Thus, it is desirable to provide a single high capacity sprinkler head construction which can be modified to suit the desired conditions by simply changing the size of the nozzle outlet. Moreover, high capacity sprinkler heads must be readily adapted for use with pressure sources ranging from 60 p.s.i. to 130 p.s.i.

The efficiency of any sprinkler is, of course, determined by the effectiveness with which it can distribute the water available to the area to be covered. The effectiveness of the distribution of water by a high capacity sprinkler head of the type which is incrementally rotated in response to the oscillation of an impulse arm is dependent upon two primary functions, first, the distance of incremental rotational movement or the incremental rotational displacement and second, the rate at which the incremental rotational movement takes place or the frequency of incremental rotation.

With respect to incremental rotational displacement, an optimum condition is one in which a minimum overlap between adjacent incremental areas receiving water is achieved. Too little displacement can result in too much overlap between incremental areas and hence too much water falling on the overlap area resulting in possible soil and crop damage. On the other hand, too much displacement can result in a gap between adjacent incremental areas receiving water which gap is not adequately irrigated. Incremental rotational displacement is determined by the frictional force of the brake used to control rotation and the impulse force applied to effect rotation under the control of the brake friction.

With respect to frequency of incremental rotation, an optimum condition is to obtain distribution in each incremental area receiving water which extends outwardly in a stream as far as the source pressure permits while still insuring adequate coverage at the inner extent of the incremental area by break up of the stream. Too low a frequency can result in the outer reaches of the incremental area receiving too much water with the attendant possibility of soil and crop damage and the inner reaches not being adequately covered. To high a frequency can result in the outer reaches of the incremental area not being adequately covered. The frequency of incremental rotation is, of course, the same as the frequency of impulse arm oscillation and it is determined by the impulse force applied by the stream to effect the impulse stroke of the impulse arm and the manner in which the return stroke of the impulse arm is accomplished. It is unaffected by the frictional force applied by the brake to control the amount of incremental rotation.

An exemplary incremental rotation displacement which will give effective distribution is within the range of 0.9° to 1.6°. An exemplary frequency of incremental rotation which will give effective distribution is within the range of 45 to 50 oscillatory cycles per minute.

It can be seen that any given sprinkler head can be constructed to operate within these ranges under any given water source condition, however, because high capacity sprinkler heads must be capable of operating under a wide range of pressure source conditions, it has been the practice heretofore to provide manual adjustments which can be made by the operator where different pressure source conditions are encountered or contemplated.

For example, in the aforesaid U. S. Pat., the reaction element is adjustably mounted on the outer end of the impulse arm so as to permit the reaction element to be retained in a plurality of adjusted positions wherein the angle of the reaction surface to the stream is varied to vary the frequency of the incremental rotational movement for the particular nozzle size and pressure source utilized. Moreover, a compensating adjustment to the brake pressure controlling the rotational movement may also be required to vary the incremental rotational displacement. It will be noted, however, that these adjustments must be made manually so that where the pressure source conditions vary during operation, the necessary adjustments are, as a practical matter, simply not made.

While adjustments of this type provide a measure of flexibility in operation, they are subject to accidental displacement from their adjusted position. Moreover, in situations where the reactant element is adjusted to accommodate low pressures and the sprinkler head is subjected to a high-pressure source, excessive vibrations and impact while operating under such high-pressure source can cause severe damage. For these reasons as well as the inconvenience to the operator in effecting adjustment, it is desirable to provide a sprinkler head which is operable under a wide range of pressure conditions and in a wide range of nozzle outlet orifice sizes to provide a substantially constant frequency of incremental rotation without the necessity of adjustment.

In my earlier application, Ser. No. 823,026, filed May 8, 1969, there is disclosed a high capacity sprinkler head which accomplishes the results noted above by providing fixed surface means on the reactant element of the impulse arm defining reactant areas for accomplishing both the oscillation of the impulse arm and the incremental rotation of the sprinkler body which vary in response to the energy conditions of the stream issuing from the nozzle. Thus, as the pressure source and/or nozzle size increases, the reactant areas of the surfaces fixed on the reactant element which are engaged by the stream decrease so that the resultant product of the energy level of the stream and the reactant areas engaged thereby are generally constant resulting in a generally constant reaction force on the impulse arm both to effect the oscillatory movement thereof and the incremental rotational movement of the sprinkler body.

It is an object of the present invention to provide a high capacity sprinkler head operable to accomplish the same results as the high capacity sprinkler head of my earlier application with a different principle of operation. In accordance with the principles of the present invention, the results are accomplished by providing reactant mans on the impulse arm providing surface area engageable by the stream which establishes an impulse force for effecting the impulse stroke of the impulse arm and the incremental rotational movement of the sprinkler body by changing the direction of movement of the stream engaged thereby. The impulse force thus established is maintained generally constant by mounting the reactant means on the impulse arm for movement with respect to the impulse arm into different positions varying the change in direction of the movement of the stream engaged thereby in response to variations in the energy of the engaged stream.

Another object of the present invention is the provision of a sprinkler head of the type described in which the reactant means is provided by a reactant element which is pivotally mounted on the impulse arm and resiliently biased into a limiting position effecting a maximum stream deflection when the stream is at a relatively low energy level. With this arrangement, the pivoted spring biased reactant element will resiliently yield in response to an increase in the energy level of the stream above the relatively low value so as to deflect the stream through an angle which is proportionately less, thus maintaining the resultant impulse force established generally constant.

Another object of the present invention is the provision of a sprinkler head of the type described having a movable spring urged reactant element which is mounted for pivotal movement about an axis which is disposed approximately 45° from the axis of oscillatory movement of the impulse arm and approximately 45° from the axis of rotation of the sprinkler body, the reactant element having reactant surfaces the major portion of which are disposed within a flat plane which is either coincident with or parallel to the pivotal axis of the reactant element.

In many uses of high capacity sprinkler heads it is desirable to cover an area which is less than a full circle. For example, when such sprinkler heads are mounted on a traveling vehicle it is sometimes desirable to leave the area in front of the vehicle dry and to provide a pattern of precipitation which extends approximately 270° or 300° so as to cover the area at the sides and rear of the vehicle only. Various mechanisms have been provided in the prior art for accomplishing part-circle sprinkling. For example, in the aforesaid U.S. Pat. there is provided a second reactant element which is moved into the stream issuing from the nozzle when the sprinkler body reaches one end of its rotational movement. The reaction of the stream on the second reactant element effects a continuous rotation of the sprinkler body in a direction opposed to the normal operating direction of the sprinkler head and when the sprinkler body reaches the beginning of its rotational movement the second reactant element is moved out of the stream, permitting the impulse arm to commence normal operation. Reversing mechanisms of this type are considered desirable since they commence the normal operation at the position within the area to be sprinkled which is the driest.

In my aforesaid copending application, there is disclosed a reversing arm mechanism which is maintained within the stream issuing from the nozzle by the reaction of the stream itself so that accidental startup during the reverse cycle can not take place, the reversing reactant element being normally biased out of the stream and positively moved into the stream against such bias and positively moved out of the stream against the action of the stream by an overriding cam arrangement which prevents jamming and breakage which may occur where the movement of the reversing reactant element into and out of the stream is accomplished by the engagement of stops or the like.

Even with an arrangement such as disclosed in my prior application, as well as with conventional reversing mechanisms such as disclosed in the aforesaid patent, it is desirable to limit the reversing speed of the sprinkler body by the reversing mechanism so as to prevent possible damage and to maintain a generally constant reversing speed so as to maintain a constant cycle speed. Where the reversing force is created by a reactant element which is fixed within the stream, the reversing force and hence the reversing speed will increase as the energy level of the stream increases.

In accordance with the principles of the present invention the portion of the reversing reactant element providing a reactant surface area for effecting the reversing. movement can be mounted on the reversing arm for resiliently biased pivotal movement in a manner similar to that of the impulse arm so as to automatically compensate for changes in the energy level of the stream and thus produce a generally constant reversing force and speed.

Accordingly, it is an object of the present invention to provide a part-circle sprinkler head of the type described having improved means for maintaining a generally constant reversing speed irrespective of the energy level of the stream.

A further object of the present invention is to provide a high capacity sprinkler head of the type described which is simple in construction, efficient in operation and economical to manufacture and maintain.

These and other objects of the present invention will become more apparent during the course of the following detailed description and appended claims.

The invention may best be understood with reference to the accompanying drawings wherein an illustrative embodiment is shown.

In the drawings:

FIG. 1 is a perspective view of a high capacity sprinkler head embodying the principles of the present invention;

FIG. 2 is a side elevational view of the swivel and spring brake assembly of the sprinkler head shown in FIG. 1 with parts broken away for purposes of clearer illustration;

FIG. 3 is an enlarged fragmentary sectional view taken substantially along the line 3—3 of FIG. 1;

FIG. 4 is an enlarged fragmentary top plan view of the impulse arm assembly showing the relationship of the reactant element thereof with the nozzle of the sprinkler body;

FIG. 5 is a sectional view taken along the line 5—5 of FIG. 4;

FIG. 6 is a side elevational view of the structure shown in FIG. 4;

FIG. 7 is a view similar to FIG. 4 showing the movable vane of the reactant element in an operative position assumed under relatively high energy level stream conditions;

FIG. 8 is a fragmentary sectional view taken along the line 8 8 of FIG. 3;

FIG. 9 is a fragmentary sectional view taken along the line 9—9 of FIG. 3;

FIG. 10 is a fragmentary side elevational view of the reversing arm assembly showing the relationship of the reactant element thereof with the nozzle of the sprinkler body;

FIG. 11 is a fragmentary top plan view of the structure shown in FIG. 10;

FIG. 12 is a view similar to FIG. 11 showing the operative position of the reactant element under relatively high energy stream conditions; and

FIG. 13 is a fragmentary top plan view of the sprinkler head with certain parts broken away for purposes of clearer illustration, showing one position of adjustment of the can elements of the reversing arm actuating mechanism with the path of movement of the cam roller shown in phantom lines therein.

Referring now more particularly to the drawings, there is shown in FIG. 1 thereof a sprinkler head, generally indicated at 10, embodying the principles of the present invention. It will be understood that the sprinkler head 10 is adapted to be mounted on the upper end of a riser pipe, the lower end of which is communicated through suitable conduit to a source of water under pressure. Where the head 10 is used to sprinkler irrigate, the riser may be stationarily mounted in the field or may be carried by a traveling vehicle. For example, the

sprinkler head **10** of the present invention would find particular utility in a traveling sprinkler irrigation device of the type disclosed in commonly assigned U.S. Pat. No. 3,507,336 dated Apr. 21, 1970.

The sprinkler head **10** of the present invention includes, in general, a swivel and spring brake assembly, generally indicated at **12**, which is adapted to be connected at its lower end with the riser. A sprinkler body, generally indicated at **14**, is connected with the upper end of the swivel and spring brake assembly in hydraulic communication with the riser pipe for directing the flow of water upwardly and outwardly, the swivel and spring brake assembly **12** mounting the sprinkler body for controlled rotational movement about a generally vertical axis. The sprinkler body **14** directs the water under pressure communicated therewith in a stream flowing therefrom in generally symmetrical relation to a plane passing through the axis of rotation.

An impulse arm assembly, generally indicated at **16**, is pivotally mounted on the sprinkler body for oscillatory movement about an axis extending transverse to the aforesaid plane. The impulse arm assembly **16** includes a reactant means, generally indicated at **18**, on the outer end thereof and is normally biased into a limited position wherein the reactant means **18** is disposed within the path of a stream issuing from the sprinkle body. The reactant means **18** is operable in response to the energy of a stream issuing from the sprinkler body to effect movement of the arm through repeated oscillatory cycles, each of which includes an impulse stroke wherein the reactant means leaves the stream and moves away from the latter in one direction and a return stroke wherein the reactant means moves in the opposite direction toward the stream and enters the latter. The reactant means **18** is also operable during the portion of each oscillatory cycle when it is disposed within the stream to impart an incremental rotational movement to the sprinkler head which is controlled by the swivel and spring brake assembly **12**.

The sprinkler head **10** also includes a reversing arm assembly, generally indicated at **20**, which is pivotally mounted on the sprinkler body for oscillatory movement about an axis extending transverse to the aforesaid plane and which, preferably, is concentric with the pivotal axis of the impulse arm assembly **16**. The reversing arm assembly **20** includes a reversing reactant means **22** on the outer end thereof and is normally biased into a limited position wherein the reactant means **22** is disposed out of the path of a stream issuing from the sprinkler body. The reversing arm assembly **20** is adapted to be used when it is desired to sprinkler irrigate an area less than a full circle, as for example, a segmental portion of a circle proceeding from one end thereof to the opposite end thereof. The reversing arm assembly **20** is operable to rotate the sprinkler head from the opposite end back to the one end and in order to accomplish this operation, there is provided a reversing arm actuating mechanism, generally indicated at **24**, which is operable in response to the sprinkler body reaching the opposite end of its rotation to effect a pivotal movement of the reversing arm assembly from its normally biased position into a position wherein the reversing reactant means **22** is engaged by the stream issuing from the sprinkler body and maintained therein by the stream against its normal bias. The reversing arm actuating mechanism **24** is operable, in response to the reversing rotational movement of the sprinkler body back to its one end, to effect a pivotal movement of the reversing arm assembly **20** back into its normally biased position wherein the reactant element **22** is disposed out of the path of the stream.

Referring now more particularly to FIG. **2**, there is shown therein a preferred embodiment of the swivel and spring brake assembly **12**. While it will be understood the assembly **12** may assume many different forms, as shown, there is provided a lower fitting **26** having connecting means thereon for engagement with the upper end of the riser pipe as, for example, interior threads **28**. The fitting **26** is provided with an annular flange **30** extending radially outwardly from the upper end thereof for sealing engagement with a radially extending annular flange **32** formed on the lower end of a swivel housing member **34**. Any suitable means may be provided for securing the fitting **26** and housing member together in sealing relation as, for example, a plurality of circumferentially spaced bolt assemblies **36** extending through the flanges **30** and **32** and a sealing gasket **38** mounted between the flanges **30** and **32**.

Disposed within the swivel housing **34** is the lower end of an elbow member **40** which forms a part of the sprinkler body **14**. As best shown in FIG. **2**, the lower outer periphery of the elbow member **40** has a bearing sleeve **42** formed thereon which provides an exterior sealing surface for an O-ring **44** carried in a suitable annular groove formed on the interior periphery of the swivel housing **34**. Formed on the outer periphery of the elbow member **40** in upwardly spaced relation from the bearing **42** is a downwardly facing annular shoulder **46** arranged to receive the inner race of a ball bearing assembly **48** thereagainst. The ball bearing assembly **48** may be retained in engagement with the shoulder **46** by any suitable means such as a retainer ring **50** or the like. The outer race of the ball bearing assembly **48** seats within an upwardly facing shoulder **52** formed in the upper interior periphery of the swivel housing **34**.

The upper end of the swivel housing member **34** has an annular flange **54** extending radially outwardly therefrom which is provided with a series of circumferentially spaced vertical openings for receiving a corresponding series of bolt assemblies **56**. The bolt assemblies **56** serve to fasten an annular cover member **58** on the upper surface of the flange **54** which has an inner peripheral portion disposed in engagement with the outer race of the ball bearing assembly **48**.

Formed on the exterior periphery of the elbow member **40** in vertically spaced relation to the cover member **58** is an annular flange **60** which extends radially outwardly therefrom. The flange **60** is formed with a series of circumferentially spaced openings for receiving a series of bolts **62** therethrough which threadedly engage within an annular friction ring **64** to thus secure the latter beneath the annular flange **60**. The friction ring **64** includes an upwardly facing outer annular friction surface **66** which is engaged by a downwardly facing annular friction surface of a brake ring **68**.

The brake ring **68** is provided with a series of circumferentially spaced apertured lugs and certain of the bolt assemblies **56** are provided with extensions **70** which extend upwardly therethrough. Mounted over each of the bolt extensions **70** is a spring spacer **72** disposed in engagement with the upper surface of the brake ring and having a coil spring **74** mounted in surrounding relation thereto. The upper end of each coil spring **74** is engaged by a washer **76** and a nut **78** threaded on the upper extremity of the bolt extension **70** serves as a means for adjusting the brake spring pressure. It will be noted that the outer peripheral portion of the friction ring **64** and adjacent peripheral portion of the cover **58** are formed with outwardly diverging annular surfaces for receiving an annular O-ring seal **80** in sealing engagement therewith.

The elbow member **40**, which forms a part of the sprinkler body, curves upwardly from the flange **60** and has an auxiliary outlet **82** communicating with the interior thereof having its axis disposed at an angle of approximately 20° with respect to the horizontal. As shown, the auxiliary outlet **82** has a plug **84** sealingly secured within the outer end thereof, although it will be understood that the plug may be replaced with a suitable spreader nozzle if desired, in accordance with conventional practice. The elbow member **40** also includes a vertical opening **86** extending downwardly into communication with the interior thereof which likewise is normally plugged but which, when the plug is removed, is adapted to receive a pressure gauge G, as shown in FIG. **1**.

Fixedly secured to the upper end of the elbow member **40**, as by welding or the like, is the lower end of a tubular barrel member **88** which likewise forms a part of the sprinkler body **14**. As best shown in FIGS. **2** and **3**, the inner periphery of the barrel member is provided with a series of circumferentially

spaced flow guiding fins or ribs **90** which extend radially inwardly from the interior periphery thereof. In the embodiment shown in FIG. **1**, the axis of the tubular barrel member **88** is disposed at an angle of approximately 27° with respect to the horizontal although it will be understood that this angle may be varied. For example, an angle of approximately 21° is desirable where it is expected that the sprinkler head will be used extensively under strong wind conditions.

Detachably secured to the upper outer end of the barrel member **88** is a nozzle member **92**. It will be understood that the nozzle member **92** may be provided with a tapered bore orifice in which case it is necessary to replace the entire nozzle member to change the orifice size. Alternatively, the nozzle member may have a ring insert detachably secured therein which forms the outlet orifice providing the operator with the option of changing orifice size merely by the selection of a desired ring size. Exemplary taper bore nozzle member sizes in diameter dimension expressed in inches, are 1.05, 1.2, 1.3, 1.4, 1.5, 1.6 and 1.75. Exemplary ring insert orifice sizes are 1¼, 1⅜, 1½, 1⅝, 1¾, and 2.

Referring now more particularly to FIG. **3**, the preferred manner of pivotally mounting the impulse arm assembly **16** to the sprinkler body **14** is shown therein. Fixedly secured, by any suitable means, such as welding or the like, to the upper periphery of the barrel member **88**, in spaced relation to the nozzle member **92**, is a saddle member **94**. The saddle member **94** is provided with a transverse bore **96** through which a shaft **98** extends with its ends disposed outwardly on each side of the barrel member **88**. The impulse arm assembly **16** includes a tubular hub portion **100** within which one end of the shaft **98** is disposed. The hub **100** is journaled on the shaft by any suitable means, such as a pair of axially spaced roller bearing assemblies **102** mounted between the inner periphery of the hub portion and the outer periphery of the shaft. The inner races of the bearing assemblies are retained in spaced relation by a spacer sleeve **104** disposed in surrounding relation to the shaft between the bearing assemblies.

Pivotally mounted on the portion of the shaft **98** between the impulse arm assembly **16** and the saddle member **98** is a counterweight member **106**. The counterweight member includes a tubular hub portion **108** which is journaled on the shaft **98** by any suitable means, such as a ball bearing assembly **110** having its outer race engaged with the inner periphery of the hub portion **108** and its inner race engaged with the periphery of the shaft **98**. The counterweight member **106** is maintained in axially spaced relation between the impulse arm assembly and the saddle **94** by a spacer sleeve **112**, similar to the sleeve **104** positioned between the inner races of the adjacent bearing assemblies of the impulse arm assembly and the counterweight member and a centering spacer **114**, one end of which engages the inner race of the bearing assembly **112** and the opposite end of which is formed into a frustoconical configuration to engate within a similarly shaped surface on the adjacent end of the bore **96**.

The outer end of the shaft **98** has a nut **116** threadedly engaged thereon which nut contacts the inner race of the adjacent bearing assembly **102**. The portion of the shaft adjacent the opposite end of the bore **96** includes an enlarged section **118** upon which a centering nut **120** is threadedly engaged. It can be seen that the bearing assemblies and spacers as well as the shaft **98** will be fixedly secured to the saddle member **94** by tightening the nuts **116** and **120**.

Preferably, the bearing assemblies **102** and **110** are sealed for lifetime lubrication. To this end, a cap **122** is detachably engaged within the outer end of the hub portion **100**, as by a retainer ring **124**, the cap having an O-ring **126** providing a seal for the periphery of the hub portion adjacent its outer end. The opposite inner end of the hub portion is sealed by an annular sealing assembly **128** of any conventional design. In a like manner, the opposite ends of the hub portion **108** are provided with annular sealing assemblies **130** which likewise may be of any conventional design.

Referring now more particularly to FIG. **8**, it will be noted that the impulse arm assembly is formed with a lug **132** which extends transversely beyond the hub portion in rearwardly spaced relation thereto. The lug **132** includes a lower abutment surface **134** which is adapted to engate an upwardly facing abutment surface **136** provided on the saddle member **94** in the path of movement of the abutment surface **134**. The position of the hub portion **100** of the impulse arm assembly with respect to the reactant element **18** on the forward end thereof and with respect to a counterweight **138** on the opposite end thereof is such that the impulse arm assembly under static conditions is biased to pivot in a clockwise direction as viewed in FIG. **8**. This normal biased clockwise movement is limited by the engagement of abutment surfaces **134** and **136**. In this way, when the sprinkler head is not in operation, the impulse arm assembly **16** is normally biased into a limiting position in which the reactant element **18** is disposed in a position to be engaged by the stream when operation is commenced by communicating the sprinkler head with a source of water under pressure. While the counterweight **138** is of a size to normally bias the reactant element **18** upwardly into its normal limiting position, the shape of the counterweight **138** is chosen so as to present a surface area generally equal to the surface area of the reactant element so as to minimize the tendency of the impulse arm assembly to be moved by high winds.

As best shown in FIG. **8**, the counterweight member **106** is positioned substantially entirely in one radial direction from the hub portion **108** and is retained in a position extending in a direction generally parallel with the extent of the barrel member **88**. To this end, the saddle member **94** is formed with a transversely extending lug **140** which is apertured to threadedly receive a bumper member **142**. The counterweight member **106** includes an integral transversely extending lug **144** disposed in a position to engage the bumper member **142** when the counterweight member is disposed in its normal inoperative position as shown in FIG. **8**. The rearwardly and downwardly facing surface of the bumper member **140** and the forwardly and upwardly facing surface of the lug **144** constitute interengaging abutments which retain the counterweight member in its normal inoperative position when the impulse arm assembly **16** is in its normal inoperative position.

The counterweight member **106** also includes a second radially extending lug **146** which is adapted to be engaged by a bumper member **148** threadedly engaged within the lug **132** of the impulse arm assembly. With this arrangement, during the pivotal movement of the impulse arm assembly away from its normal inoperative position, after a travel of approximately 63°, the forwardly facing abutment surface of the bumper member **148** will engage the rearwardly facing abutment surface of the lug **146** so that in subsequent pivotal movement during the impulse stroke the counterweight member **106** is carried with the impulse arm. Likewise, during the initial portion of the return stroke, the counterweight member **106** becomes effectively a part of the impulse arm assembly until the abutment surface of the lug **144** engages the abutment surface of the bumper **142** at which time the movement of the counterweight member is stopped while the impulse arm assembly continues to move through the completion of its return stroke.

Referring now more particularly to FIGS. **4–7**, the construction of the reactant means **18**, which forms an important part of the present invention, can best be seen. The reactant means **18** includes an arm attaching element **150** one end portion of which is rigidly secured to the outer end of the impulse arm assembly **16** by any suitable means, such as a pair of bolt assemblies **152**. One or more of the openings through which the bolt assemblies **152** extend may be transversely elongated to permit the attaching element to be precisely positioned and secured. Such an adjustment however is provided for manufacturing accuracy to compensate for the tolerances in the manufacture. It is contemplated that the securement of the attaching element **150** to the impulse arm assembly will be a permanent rigid factory securement and it is not intended that

the adjustment provided is for the purpose of adjustment by the operator after purchase.

As best shown in FIG. **5**, the arm attaching element **150** extends laterally outwardly from one side of the impulse arm assembly **16** and then upwardly and outwardly at an angle of approximately 45°. The outer end portion of the attaching element is best upwardly and then at a right angle inwardly to provide a stream engaging end portion **154**. The stream engaging edge of the portion **154** is formed with a downwardly and outwardly facing reactant surface area **156** which serves to initially engage the stream during the return stroke of the impulse arm assembly and to deflect the stream downwardly so as to establish a reaction force on the impulse arm assembly tending to move the reaction arm farther into the stream and toward its limiting position.

The reactant means **18** further includes a movable reactant element generally indicated at **158**. As best shown in FIGS. **4–6** the movable reactant element is formed from a plate or the like and positioned to have a vanelike effect on the stream so as to deflect the movement of the stream and as a result of this deflection establish an impulse force which acts on the impulse arm assembly through a lever arm greater than the lever arm of the reactant force established by the reactant surface area **156**. The major portion of the reactant element provides a relatively flat central reactant area **160**. The lower longitudinal edge of the reactant area **160** is bounded by a wall **162** which extends upwardly from the surface at right angles thereto and the other longitudinal edge of the reactant surface area **160** is bounded by a wall **164** which extends forwardly therefrom at an angle of approximately 135°.

As shown, the reactant element **158** is preferably made of a rigid material such as metal or the like and is pivotally mounted with respect to the attaching element **150** and spring urged into a normal limiting position. It will be understood that equivalent arrangements may be utilized as, for example, the reactant element could be made of a resilient material itself so as to permit resilient yielding movement. As shown, however, the adjacent edge portions of the movable element **158** and attaching elements are provided with pairs of aligned lugs **166** and **168** respectively, each pair of adjacent aligned lugs having a pivot pin **170** extending therethrough. As shown, the pivotal axis provided by the pivot pins **170** is at an angle of approximately 45° both with respect to the pivot axis of the impulse arm assembly **16** and the rotational axis of the sprinkler body. The reactant surface area **160** extends parallel the the pivotal axis provided by the pivot pins **170** and in its normally biased position extends at an angle of approximately 35° from the adjacent surface of the attaching element **150**.

The resilient biasing of the movable reactant element **158**, as shown, is provided by a helical tension spring **172** having one end thereof connected with a lug **174** extending upwardly from the attaching element at a point adjacent the impulse arm. The opposite end of the spring **172** is connected with an upstanding lug **176** rigidly attached to the adjacent portion of the reactant element **158**.

OPERATION OF THE IMPULSE ARM ASSEMBLY

As previously noted, when the sprinkler head **10** is in an inoperative condition, the mass of the counterweight **138** on the rearward end of the impulse arm assembly **16** is such as to bias the impulse arm to pivot in a clockwise direction as viewed in FIG. **8**. This pivotal movement is limited by the engagement of abutment surface **134** of the lug **132** fixed to the impulse arm assembly with the surface **136** formed on the saddle member **94** and fixed with respect to the barrel member **88** (see FIG. **8**). When disposed in the normally biased limiting position with abutment surfaces **134** and **136** in engagement, the reactant means **18** is disposed so as to be in the path of the stream issuing from the nozzle **92** where the sprinkler head is in communication with a source of water under pressure. This normally biased limiting position of the reactant means constitutes the maximum extent to which the reactant means enters the stream and, consequently, upon establishment of communication of a source of water under pressure with the sprinkler head **10**, the impulse arm assembly will commence operation.

The action of the stream on the reactant means **18** when the latter is disposed within the stream is such as to effect oscillatory cycles of the impulse arm and incremental rotational movement of the sprinkler body about its axis of rotation. The oscillatory cycle includes an impulse stroke during which the reactant means leaves the stream and moves in a direction away from the stream and a return stroke in which the reactant means moves toward the stream and then enters the stream.

As can be seen in FIG **6**, the reactant surface area **156** will present first a sharp edge and then a surface so disposed with respect to the direction of the stream as to create a component of force that will tend to pull the reactant arm into the stream and toward its limiting position.

During the time that the reactant means **18** is within the stream, the stream will impinge upon the movable reactant element **158** and be deflected as shown in FIGS. **4**, **6** and **7**. The angular dispositions of the reactant surface area **160** and walls **162** and **164** with respect to the direction of the stream are such that the deflection of the stream will create a resultant reaction force, one component of which will be generally tangent to the pivotal axis of the impulse arm **16** and of sufficient magnitude to move the impulse arm through its impulse stroke. Another component also will be established which will be generally tangent to the rotational axis of the sprinkler body and sufficient to impart an incremental rotational movement to the sprinkler body under the control of the swivel and spring brake assembly **12**. A preferred angular disposition of reactant surface area **160** in its normally biased position is 35° from the adjacent surface of the attaching element **150**.

As previously noted, the distribution effectiveness of the sprinkler head on the area to be watered is determined by the rate of incremental rotation of the sprinkler body about its rotational axis. In addition, since the entrance of the reactant means **18** into the stream is utilized to break up the stream and provide adequate water to the portion of the area to be sprinkled proximate the sprinkler head, the distribution effectiveness is further determined to this extent by the oscillatory rate of the impulse arm assembly.

Efficient agricultural sprinkling irrigation requires that the precipitation rate be maintained within a relatively limited range. It is important that enough water be provided to insure penetration to the roots of the plants, whereas the application of too much water will result in inefficient runoff.

An important functional attribute of the present sprinkler head is that it is capable of maintaining a generally constant precipitation rate throughout a wide range of pressure source conditions and throughout a wide range of nozzle sizes. This generally constant precipitation rate is obtained by maintaining a generally constant incremental rotation rate of the sprinkler body and a generally constant oscillatory rate of the impulse arm assembly. FIGS. **4** and **7** illustrate how the reactant means **18** of the present invention functions under different pressure sources conditions to achieve this result. FIG. **4** is illustrative of the operation of the reactant means **18** under a pressure condition that is low relative to the pressure condition exemplified in FIG. **7**. In FIG. **4**, the energy of the stream issuing from the nozzle which is substantially all in the form of velocity energy is insufficient to overcome the biasing force of spring **172** to pivot the reactant element **158** about the pivot axis provided by the pivot pins **170**. As a result, the surface area on the reactant element **158** that is impacted by the stream will effect a maximum stream deflection with a pressure condition that is insufficient to pivot reactant element **158**.

FIG. **7** illustrates the operation of the reactant means **18** under a higher pressure condition than shown in FIG. **4**. The energy of the stream is represented to be of a magnitude suffi-

cient to pivot the reactant element **158** thereby distending the spring **172**. As a result of this pivot movement of the reactant element **158**, the angular orientation of the surface area on the reactant element **158** will effect a smaller degree of stream deflection in the course of time elapsed during the stream's impingement thereon.

Since the resultant force acting on reactant element **158** is a function of the product of the velocity energy of the stream and the angle of stream deflection, it will be seen that the magnitude of the resultant force is maintained at an approximately constant value throughout a wide range of pressure source conditions and throughout a wide range of nozzle sizes due to the variability of the effective angle of the reactant surface area in direct response to a variation in pressure source condition within the range. More specifically, for every increase in the energy level of the stream, there will be a corresponding decrease in the angle of stream deflection by virtue of the angular movement of reactant element **158** away from the stream.

It will be understood that as the resultant force acting on the reactant element **158** is maintained at a generally constant value, the component force tending to move the impulse arm through its impulse stroke and the component force tending to impart an incremental rotational movement to the sprinkler body will both be maintained at an approximately constant value for the same wide range of pressure source conditions and nozzle sizes.

It can be seen therefore, that since the force components which effect the impulse stroke of the impulse arm and the intermittent rotational movement of the sprinkler body are generally constant irrespective of the pressure source conditions, the rate of impulse arm oscillation and the rate of incremental rotation of the sprinkler body and, hence, the distribution effectiveness will be generally constant irrespective of the pressure source conditions. Similarly, since the reactant means **18** is self-compensating for changes in the energy level of the stream a generally constant distribution effectiveness will be achieved throughout a range of nozzle sizes since the effect of a change in nozzle size is the same as the effect of change in pressure source, namely, to change the energy level of the stream.

DESCRIPTION OF THE REVERSING ARM ASSEMBLY

It will be understood that the sprinkler head **10** as thus far described is capable of operation where the pattern of precipitation is a full circle. A reversing arm assembly **20** and reversing arm actuating mechanism **24** utilized therewith is readily adaptable for use with other sprinkler heads and the sprinkler head **10**, thus far described, can be utilized with other reversing arm assemblies and mechanisms. However, the reversing arm assembly **20** and the actuating mechanism **24** constitute a preferable construction in the present sprinkler head **10** where it is desired to irrigate in a pattern of less than a full circle.

Referring again to FIG. **3**, the reversing arm assembly **20** includes a hub portion **172** which is journaled on the shaft **98** by any suitable means, such as spaced sleeve bearings **174**. A nut **176** is threadedly engaged on the adjacent extremity of the shaft to retain the hub portion in operative position on the shaft **98**.

As shown in FIGS. **1** and **9**, the reversing arm assembly **20** includes a rearward extension **178**, the extension having a transversely, inwardly extending lug **180** formed integrally thereof. The lug **180** includes a downwardly and forwardly facing abutment surface which is adapted to engage an adjacent upwardly and rearwardly facing abutment surface **182**, formed on the saddle member **94**.

The rearward end of the extension **178** is grooved to receive one end of a spring **184**, the opposite end of which is anchored in a manner hereinafter more fully described. Spring **184** serves to resiliently bias the reversing arm assembly **20** into a limiting position wherein the abutment surface of the lug **180** is disposed in engagement with the abutment surface **182**. With the reversing arm assembly **20** in the inoperative limiting position, as shown in FIG. **1**, the reversing reactant element **22** is disposed out of the stream issuing from the nozzle **92**.

Referring to FIG. **9**, the reversing arm assembly **20** also includes a second transversely inwardly extending lug **186** which is apertured to threadedly receive a stop element **188**. The stop element includes a downwardly and forwardly facing abutment surface which is adapted to engage an upwardly and rearwardly facing abutment surface **190** formed on the saddle member **94**. The engagement of the abutment surface **190** by the abutment surface of the lug **188** serves to limit the pivotal movement of the reversing arm assembly **20** in an operative limiting position wherein the reactant element **22** is engaged within the stream issuing from nozzle **92**.

Referring to FIGS. **10**, **11** and **12**, it will be noted that the reversing reactant element **22** is formed as an integral part of the outer end of the reversing arm assembly **20**. The reversing reactant element **22** has a laterally extending wall **192** formed with a leveling surface **194** which is inclined at an angle of approximately 45° with respect to the direction of the flow of the stream when the reactant element **22** is disposed in its operative limiting position. The surface **194** provides a reactant area which, when engaged by the stream, establishes a force component generally tangent to the pivot axis of the reversing arm assembly which maintains the reactant arm assembly in its operative position against the bias of the spring **184**.

The reversing reactant element **22** also includes a second wall **196** which extends perpendicularly from the outer edge of the wall **192**. The wall **196** is provided at its edge approximate leveling surface **194** with a bore designated **201** disposed to receive and engate one end of a pivot pin **195**. Movable reversing reactant means are provided in the form of a reversing reactant surface element **198** which is mounted at one end by means of a bore **197** which engages pivot pin **195** for pivotal movement about the axis of pin **195**. Reactant surface element **198** is provided at its end remote from bore **197** with spring guiding means in the form of a depression **203** which is disposed in alignment with a depression located on the opposing face of wall **196**. A helical coil spring is disposed between wall **196** and the reversing reactant element **198** with one end engaging the depression in wall **196** and its other end engaging the depression in element **198**. The reversing reactant surface element **198** is provided with a downwardly extending lug **199** at its lower corner remote from the bore **197**. Lug **199** is provided to cooperate with a notch **193** formed in the wall **192** whereby the opposite walls of the notch **193** provide abutment stops to limit the angular movement of the reversing reactant surface element **198**.

The reversing arm actuating mechanism **24** preferably includes a lever arm **200**, the upper end of which is integrally formed with hub portion **712** of the reversing arm assembly and the lower end of which is apertured to receive a pivot pin **202**. The pivot pin also extends through a clevis **204** which is connected to one end of an elongated connecting rod **206**. As best shown in FIG. **1**, it will be noted that the lower end of the biasing spring **184** is connected with the clevis **204**.

The rearward end of the connecting rod **206** is bent transversely and pivotally engaged, as indicated at **208**, within an apertured boss formed on one leg of a generally Y-shaped yokelike lever **210**. As best shown in FIGS. **1** and **2**, the legs of the lever **210** pivotally embrace the upper end of the elbow member **40**. The lower extremity of the lever **210** is provided with a cam roller **216** which is adapted to cooperate with a pair of cam members, generally indicated at **218** and **220**.

As best shown in FIGS. **2** and **13**, the outer periphery of the cover member **58** includes an upwardly extending annular flange **222**. Each of the cam members **218** and **220** are arranged to be mounted on the annular flange **222** in any desired position of circumferential adjustment thereon. To this end, each of the cam members is provided with throat **224** which engages over the flange **222** and provides a space beneath the flange. A tightening element **226** is disposed in each space and

connected with the associated cam member in each space and connected with the associated cam member for relative vertical movement with respect thereto, as by a pin **228** extending through appropriate lugs formed on the associated cam member and the tightening element **226**, respectively, Each cam element also includes a depending, apertured boss **230** within which a securing bolt **232** is threadedly engaged. It can be seen that by tightening the bolt **232**, the inner end thereof will engage the tightening element **226** which, in turn, will move up into tight frictional engagement with the under surface of the flange, to thereby secure the cam member in adjusted position on the flange **222**.

As best shown in FIG. **13**, the cam member **218** includes an upstanding wall **234** defining an inwardly facing cam surface **236**. The cam member **220** includes an upstanding wall **238** defining an outwardly facing and inclined cam surface **240**.

OPERATION OF THE REVERSING ARM ASSEMBLY

Where it is desired to irrigate in a part circle pattern, the cam members **218** and **220** are first adjustably positioned along the annular flange **222**, in the manner previously described, to correspond with the ends of the sprinkler pattern, the cam member **218** being positioned to define the trailing end of the pattern where the operative rotation ends and the reverse rotation begins and the cam member **220** being positioned to define the leading end of the pattern where the reverse rotation ends and the operative rotation begins.

It will be understood that during normal operation of the sprinkler head **10**, the reversing arm assembly is biased by the spring **184** to an inoperative limiting position wherein the reversing reactant element **22** is disposed out of the path of the stream. The path of the center line of the cam roller **216** during the incremental rotational movement of the sprinkler body about its axis of rotation in the operative direction is shown in the phantom line indicated by a zero in FIG. **13**. As the sprinkler body reaches the end of its part circle pattern, the cam roller **216** will engage the outer end of the cam surface **236** and, upon further operative rotation of the sprinkler body, the cam roller **216** will be moved by the cam surface **236** in a generally radially inward direction towards the axis of rotation. This movement of the cam roller pivots the lever **210** in a clockwise direction as viewed in FIG. **1** which motion is transmitted to the reversing arm assembly **20** through connection link **206** and lever arm **200**. During this clockwise pivotal motion of the reversing arm assembly, the reactant element **22** thereon will be moved into the stream issuing from the nozzle. As soon as the stream engages the surface **194**, the action of the stream thereon will establish a force having a component tangential to the pivotal axis of the reversing arm assembly which will move the reversing arm assembly farther into the stream until the abutment surface of lug **188** engages the abutment surface **190**. The action of the stream on the surface **194** tends to maintain the reactant element **22** within the stream in its operative limiting position against the bias of the spring **184**.

During the time that the reactant element **22** is within the stream, the stream will impinge upon the movable reactant surface element **198** and be deflected as shown in FIGS. **11** and **12**. The angular disposition of the reactant surface element **198** with respect to the direction of the stream in such that the deflection of the stream will create a resultant reaction force having a component tangent to the axis of rotation of the sprinkler body and of sufficient magnitude to move the sprinkler body in a reverse direction. A preferred angular disposition of reactant surface element **198** with respect to the direction of the stream is such that a portion of the stream will be deflected through an angle of approximately 40° when lug **199** is in contact with the wall of notch **193** remote from wall **196** (see FIG. **11**) and through an angle of approximately 30° when lug **199** is in contact with the other wall of notch **193** (see FIG. **12**).

As previously set forth, it is desirable to limit the reversing speed of the sprinkler body **10** by the reversing mechanism so as to prevent possible damage and to maintain a generally constant reversing speed so as to maintain a constant cycle speed. To obtain this result, the operative principle embodied in the structure of the movable impulse reactant element **158** is adapted for application to the structure of the reversing mechanism. FIGS. **11** and **12** illustrate how the reversing reactant element **22** of the present invention functions under different pressure source conditions to achieve the desired operation.

FIG. **11** illustrates the operation of the reactant surface element **198** under a pressure condition that is low relative to the pressure condition represented in FIG. **12**. It can be seen that reactant surface element **198** functions in a manner analogous to the operation of the impulse reactant element **158** as shown in FIG. **4** with the difference that the angular disposition of reactant surface element **198** with respect to the stream is such that the deflection of the stream will create almost exclusively one component of force that is tangent to the axis of rotation of the sprinkler body to move the sprinkler body in a reversing direction.

More specifically, the energy level of the stream, as represented in FIG. **11**, is insufficient to pivot element **198** about its axis against the bias of spring **191**. As a result, the stream is deflected through an angle that is greater than that shown in FIG. **12** which exemplifies the operation of the reactant surface element **198** under a higher pressure source condition.

As noted previously, the resultant force as well as its component are functions of the product of the velocity energy of the stream and the angle of stream deflection. It can be seen that, since as the velocity energy level of the stream increases, the angle of stream deflection decreases, the magnitude of the resultant reaction force and its component are maintained at an approximately constant value throughout a wide range of pressure source conditions and throughout a wide range of novel sizes.

Since the reactant surface element **198** automatically compensates for changes in the energy level of the stream, a generally constant distribution effectiveness will be achieved during each reversing cycle as well as a uniform reversing speed.

The path of movement of the center cam roller **216** is shown in the phantom line indicated at R in FIG. **13**. When the cam roller **216** engages the cam surface **238** on the cam member **220** during this movement, the cam roller **216** will be moved in a generally radially outward direction by the cam surface **238**. This outward radial movement is transmitted through the lever **210**, connecting rod **206** and lever arm **200** to the reversing arm assembly **20** to move the reactant element **22** out of the stream permitting it to be biased into its inoperative limiting position by the spring **184**.

The reversing arm assembly **20** and its actuating mechanism **24** includes two significant functional attributes. First, since the reversing arm is maintained in its operative position by the stream itself, in the event that the pressure source should be shut off during a reverse stroke, the reversing arm mechanism will be biased into its inoperative limiting position as soon as the streams stops. Thus, when the operation is again commenced, the sprinkler head will proceed in a normal operative fashion to the end of the pattern before the reversing stroke is accomplished. The arrangement prevents an accidental start up in the reverse stroke. Second, the cam and the cam roller arrangement for effecting the initial movement of the reversing arm assembly into and out of the stream are overriding in operation thus eliminating any severe shocks or damage that could occur where positive stops are provided for effecting movement of the reversing arm mechanism. As shown in FIG. **13**, each of the cam surfaces **236** and **240** are disposed out of engagement with the cam roller when the associated radial movement of the cam roller **216** is accomplished.

While the sprinkler head 10 of the present invention is particularly advantageous as a high capacity agriculture irrigation sprinkler, it will be apparent that the principles of the present invention could readily be embodied in low capacity sprinkler head for use on lawns, athletic fields and the like.

It thus will be seen that the objects of this invention has been fully and effectively accomplished. It will be realized, however, that the foregoing specific embodiment has been shown and described only for the purpose of illustrating the principles of this invention and is subject to extensive change without departure from such principles. Therefore, this invention includes all modifications encompassed within the spirit and scope of the following claims.

What is claimed is:

1. A sprinkler head comprising

a sprinkler body having an inlet and an outlet,

means for mounting said sprinkler body for controlled rotational movement about a generally vertical axis with said inlet in communication with a conduit arranged to communicate a source of water under pressure therewith,

said outlet being disposed to direct water under pressure communicated with said inlet in a stream flowing therefrom in a direction upwardly and outwardly in generally symmetrical relation to a plane passing through the axis of rotation,

an impulse arm mounted with respect to said sprinkler body for pivotal movement about an axis transverse to said plane through repeated oscillatory cycles each including an impulse stroke and a return stroke, said impulse arm being biased to move through its return stroke into a limiting position,

said impulse arm having reactant means thereon providing surface area engageable by the stream issuing from said outlet when said impulse arm is disposed in said limiting position for changing the direction of movement of the stream engaged thereby to establish an impulse force having (1) a component tangential to the pivotal axis of said impulse arm for effecting an impulse stroke thereof, and (2) a component tangential to the rotational axis of said sprinkler body for effecting an incremental rotational movement thereof in one direction, and

means mounting said reactant means on said impulse arm for movement with respect to said impulse arm into different positions varying the change in direction of the movement of the stream engaged thereby in response to variations in the energy of the engaged stream so as to maintain the impulse force established thereby generally constant and hence the impulse stroke of the impulse arm and the incremental rotation of said sprinkler body effected thereby generally constant throughout a relatively wide range of variations in the energy of the stream.

2. A sprinkler head as defined in claim 1 wherein said reactant means comprises a reactant element and said mounting means comprises a pivotal connection between said reactant element and said impulse arm providing for pivotal movement of said reactant element about an axis spaced from and disposed at an angle with respect to both the axis of oscillatory movement of said impulse arm and the axis of rotation of said sprinkler body and spring means resiliently maintaining said reactant element in said limiting position when the size and energy level of the stream engaged thereby is at a relatively low predetermined valve and yieldingly permitting pivotal movement away from said limiting position an amount which increase generally proportionally to the increase in the size and energy level of the engaged stream above said relatively low predetermined value.

3. A sprinkler head as defined in claim 2 wherein said pivotal axis of said impulse arm is perpendicular to the rotational axis of said sprinkler body and wherein the pivotal axis of said reactant element is disposed at an angle of approximately 45° with respect to both the pivotal axis of said impulse arm and the rotational axis of said sprinkler body.

4. A sprinkler head as defined in claim 3 wherein the reactant area of said reactant element is primarily provided by a flat surface portion disposed in a plane parallel with the pivotal axis of said reactant element.

5. A sprinkler head as defined in claim 1 including

a reversing arm pivotally mounted with respect to said sprinkler body of oscillatory movement between operative and inoperative positions,

said reversing arm having reversing reactant means thereon providing surface area engageable by the stream issuing from said outlet when said reversing arm is disposed in said operative position for changing the direction of movement of the stream engaged thereby to establish a reversing force having a component tangential to the rotational axis of said sprinkler body for effecting reversing rotational movement in the opposite direction,

means mounting said reversing reactant means on said reversing arm for movement with respect to said reversing arm into different positions varying the change in direction of the movement of the stream engaged thereby in response to variations in the energy of the engaged stream so as to maintain the reversing force established thereby generally constant and hence the reversing rotation of said sprinkler body effected thereby generally constant throughout a relatively wide range of variations in the energy level of the stream, and

means for effecting movement of said reversing arm between said operative and inoperative positions.

6. A part circle sprinkler head comprising a sprinkler body having an inlet and an outlet,

means for mounting said sprinkler body for controlled rotational movement about a generally vertical axis with said inlet in communication with a conduit arranged to communicate a source of water under pressure therewith,

said outlet being disposed to direct water under pressure communicated with said inlet in a stream flowing therefrom in a direction upwardly and outwardly in generally symmetrical relation to a plane passing through the axis of rotation,

an impulse arm pivotally mounted with respect to said sprinkler body for oscillatory movement and having a reactant element thereon,

said impulse arm being normally biased into a limiting position wherein said reactant element is disposed within the path of a stream issuing from said outlet and having means thereon operable (1) in response to the energy of a stream issuing from said outlet to move through repeated oscillatory cycles each of which includes an impulse stroke wherein said reactant element leaves the stream and moves away from the latter in one direction and a return stroke wherein said reactant element moves in the opposite direction toward said stream and enters the latter, and (2) during each oscillatory cycle thereof to effect controlled incremental rotational movement of said sprinkler body in one direction,

a reversing arm pivotally mounted with respect to said sprinkler body of oscillatory movement between operative and inoperative positions,

said reversing arm having reversing reactant means thereon providing surface area engageable by the stream issuing from said outlet when said reversing arm is disposed in said operative position for changing the direction of movement of the stream engaged thereby to establish a reversing force having a component tangential to the rotational axis of said sprinkler body for effecting reversing rotational movement in the opposite direction,

means mounting said reversing reactant means on said reversing arm for movement with respect to said reversing arm into different positions varying the change in direction of the movement of the stream engaged thereby in response to variations in the energy of the engaged stream so as to maintain the reversing force established thereby generally constant and hence the

reversing rotation of said sprinkler body effected thereby generally constant throughout a relatively wide range of variations in the energy level of the stream, and

means for effecting movement of said reversing arm between said operative and inoperative positions.

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