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Morgan

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[54] **TIMING UNIT FOR CONNECTING POWER SEQUENTIALLY TO A PLURALITY OF STATIONS**

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[73] Assignee: **Clemar Manufacturing Corporation**, Glendora, Calif.

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[52] **U.S. Cl.** **307/141.4**; 74/568

[51] **Int. Cl.** **H01h 7/00**

[58] **Field of Search** .... 200/38 CA, 38 C, 38 D, 200/38 DA; 307/141 R, 141.4, 141.8; 340/309.6, 309.4, 309.1; 74/568

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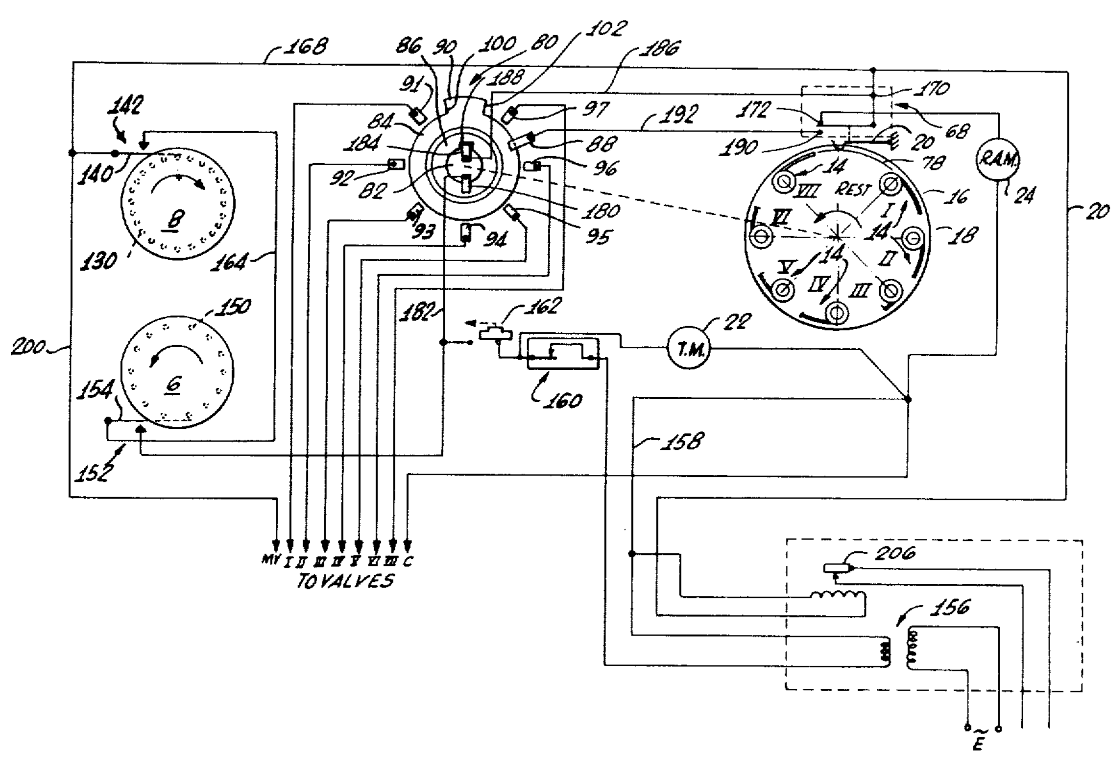
Attorney, Agent, or Firm—Fulwider, Patton, Rieber, Lee & Utecht

[57] **ABSTRACT**

A timing unit which connects power sequentially to each of a number of stations such as, for example, a number of power actuated sprinkler valves. The unit includes a rotary station timer divided peripherally into sectors including a number of station sectors each corresponding to one of the stations. Each station sector is provided with a cam unit dividing the periphery of the sector into first and second cam regions. The relative lengths of the cam regions in each sector can be selectively varied for each sector independently of the other sectors. A sensor senses the first and second cam region as each station sector passes a fixed datum. A selector connected with the station timer connects power to each station within the time that the corresponding one of the station sectors is passing the datum for the duration that the second cam region associated with the corresponding station sector is sensed by the sensor. While any of the second cam regions is being sensed, the station timer is turned at a timing speed. However when any of the first cam regions is sensed the station timer is rotated at a faster advance speed, thereby enabling the station timer to pass rapidly through the intervals between application of power to the successive stations.

23 Claims, 11 Drawing Figures



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SHEET 1

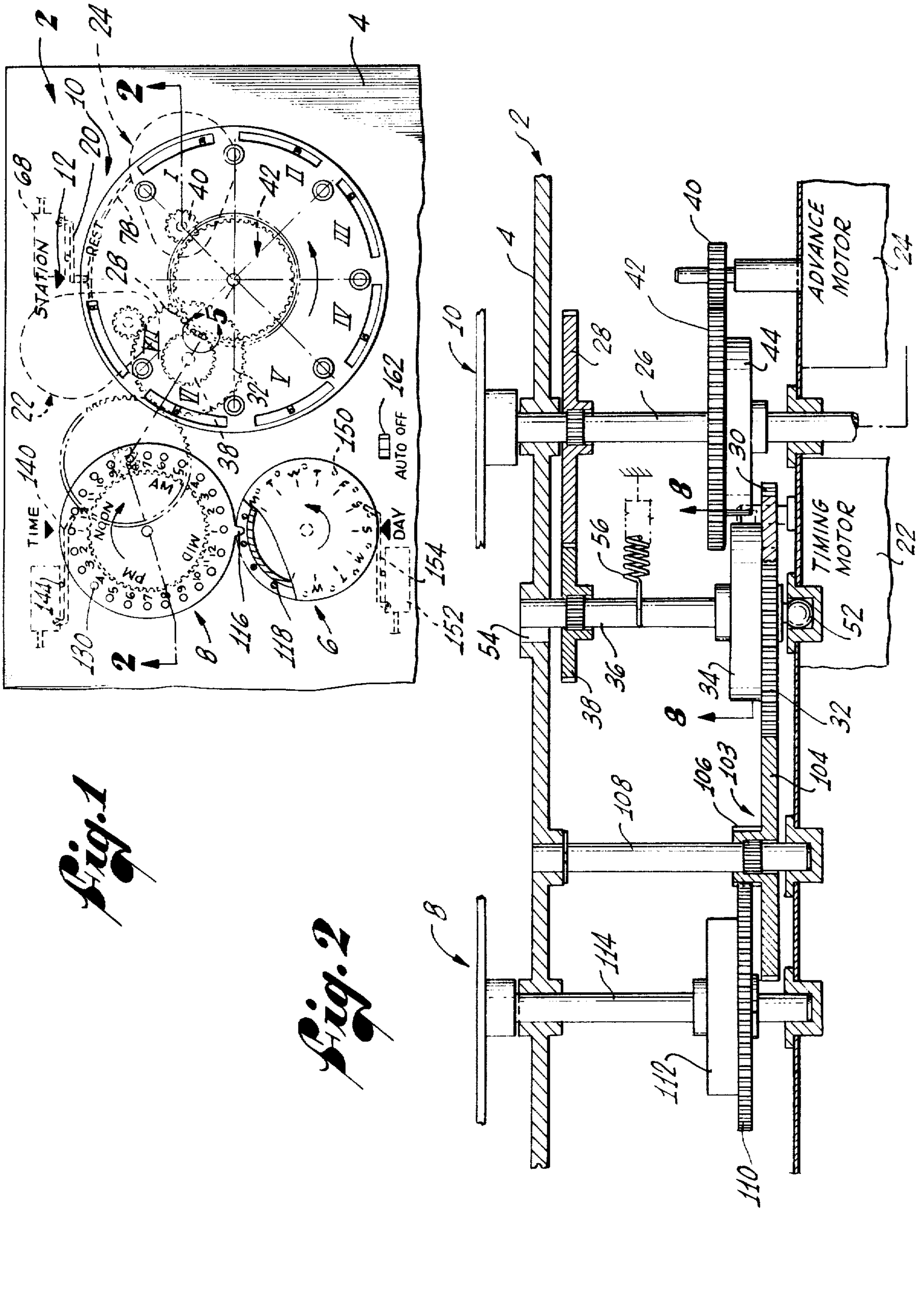

Fig. 1

Fig. 2

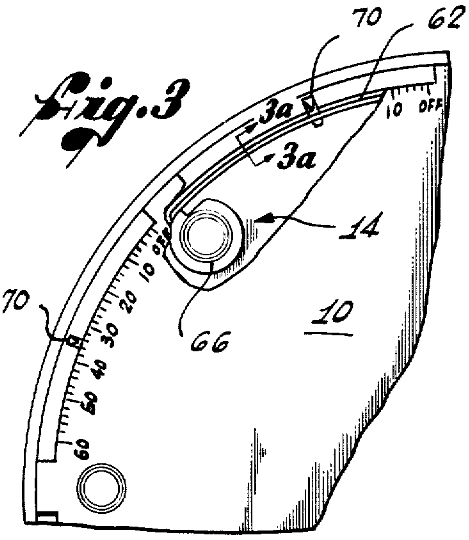

Fig.3

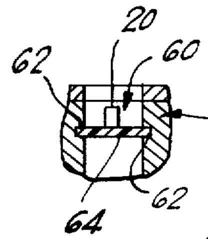

Fig.3a

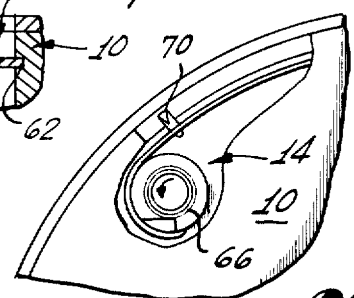

Fig.4

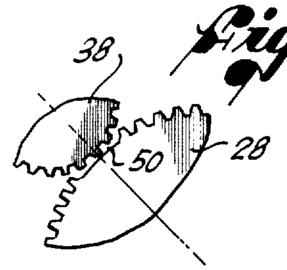

Fig.5

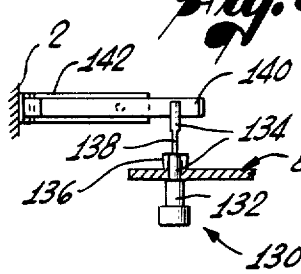

Fig.6

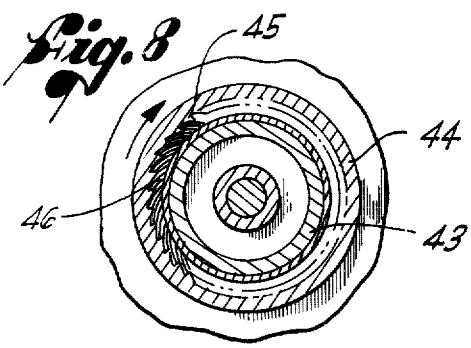

Fig.8

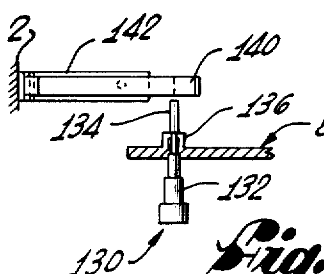

Fig.7

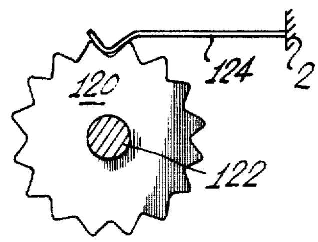

Fig.9

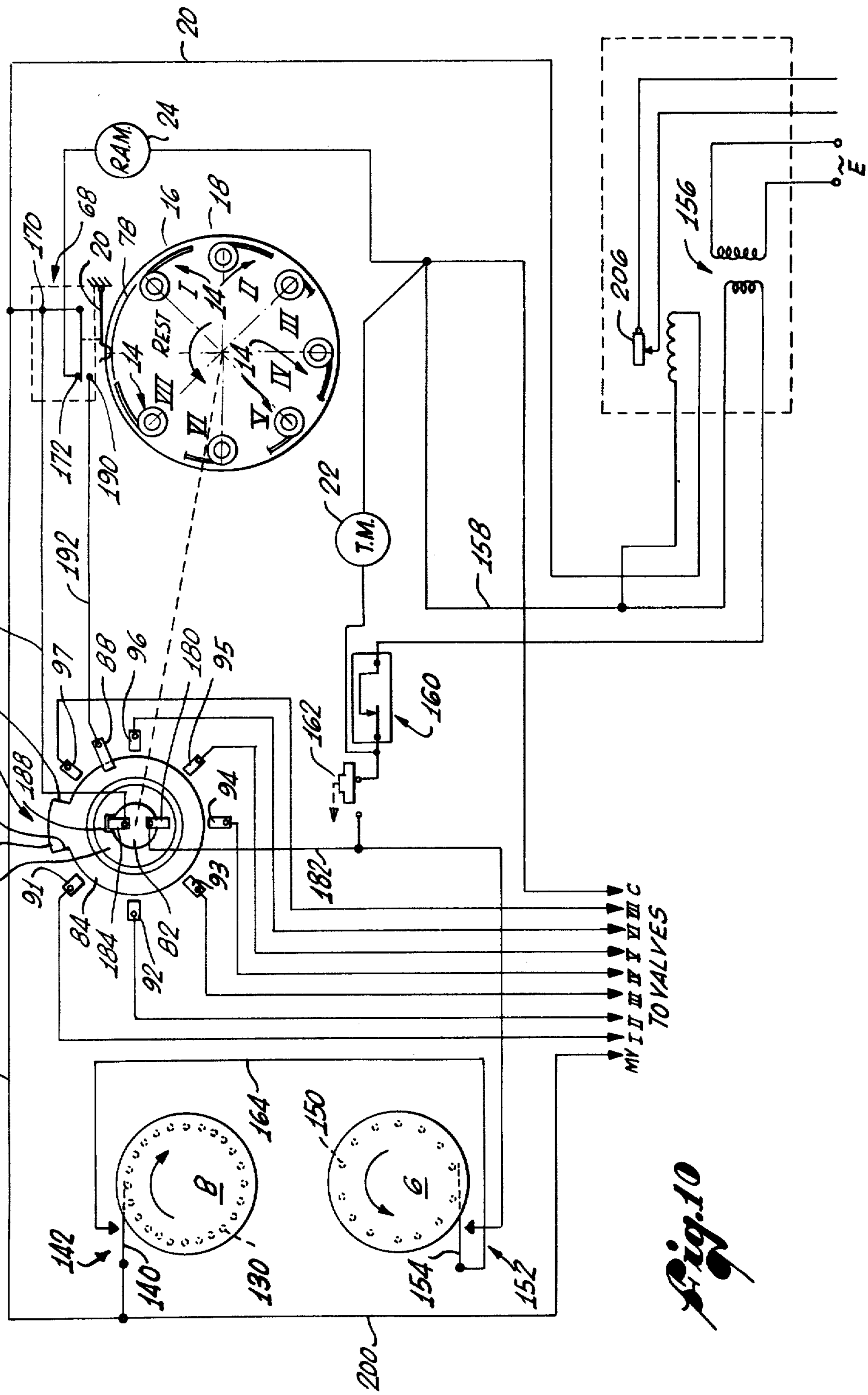

Fig.10

TIMING UNIT FOR CONNECTING POWER SEQUENTIALLY TO A PLURALITY OF STATIONS

BACKGROUND OF THE INVENTION

This invention relates to a timing unit for applying power sequentially to a number of power utilizing stations. In particular, it relates to an electromechanical timing system operable in cycles at preselected intervals to connect power to each of the stations in turn for an individually preselected period during each cycle of operation of the timing unit.

In performing automatic control of a number of power utilizing stations, such as for example, lawn sprinklers, it is known to utilize power operated mechanical timing systems. Such timing systems may include hour and day timers for preselecting the times at which operation of the stations is to be initiated and individually settable station timers for each of the stations. With such a system, each cycle of operation of the timer delivers power to each station in turn during each cycle for the individually preselected times.

One prior timer of the type described, includes a timing motor which continuously drives a 24-hour rotary timer. The hour timer is provided with a projection at one point on its periphery which engages a ratchet wheel, day timer once during each rotation thereby advancing the day timer by one day. Individually settable pins on the day timer and individually positionable clips on the hour timer can be preselected to control the operation of an adjacent rotary station timer so that it commences to rotate at the preselected times. The station timer is positioned proximate to a star wheel which turns a rotary switch step by step to connect power to each of the stations in turn. Clips are prepositioned at selected intervals about the periphery of the station timer and each time a clip passes the star wheel it engages it to advance the rotary switch by one station. Thus, the duration for which power is applied to a particular station is determined by the rate of rotation of the station timer and the peripheral spacing between the initiating clip which advances the star wheel to the particular station and the terminating clip which will advance the star wheel to the following station.

Although such prior timer may have been generally satisfactory, certain disadvantages may sometimes arise in its use. One major problem is the cumulative nature of the periodic times set by the clips on station timer. Because the time interval for any particular station is determined by the spacing between the clip which initiates power connection to that station and the following clip which advances the star wheel to the following station, a change in spacing between two clips will alter the spacing of the following clip from the next succeeding following clip which will in turn have to be adjusted. Thus, a change in the selected time at any one station involves repositioning of the clips for all the succeeding stations following the station where the change was made.

Another problem of such prior timer may arise from the difficulty of calibrating the station timer. If each station position commenced at a fixed point on the station timer, it would be possible to calibrate the position of the next following clip in a graduated scale from the starting point downstream in successively increasing time intervals. This is not possible with the system described where the position of each starting clip is not fixed because it may have to be readjusted when the preceding upstream interval is changed. As a result calibration involves positioning of all the clips along to a continuously graduated, progressively, circular scale. However the use of a continuously graduated scale involves making mental subtractions based on the difference in the scale graduations to determine the desired interval between any two particular clips. For people of limited mechanical or mathematical aptitudes who are often involved in the operation of such systems, such a calibration system is not only time consuming and difficult to operate but fraught with the possibility of error. a further disadvantage of the continuous calibration system just referred to is that it is difficult to tell how much time remains for power application at any particular station by simply looking at the station timer.

In addition, the use of clips mounted on the station timer and the 24 hour timer may also have disadvantages. Because of their projecting nature the clips are vulnerable to being knocked off and damaged. In addition, such clips have previously been attached by the use of set screws which requires that the operator have a screwdriver available whenever he wishes to change the time settings. The screws may also, in prolonged use, cause pitting about the edges of the station and hour timers which can prevent the clips from being precisely positioned if the pitting becomes extreme.

SUMMARY OF THE INVENTION

A timing unit according to the present invention is intended to connect power sequentially to each of a number of stations. The unit includes a rotary station timer mounted on a frame. The station timer is divided peripherally into sectors including a number of station sectors, each corresponding to one of the stations. At preselected intervals, the station timer commences to make one complete revolution past a fixed datum. Each of the station sectors is provided with a cam unit dividing the peripheral length of each station sector into first and second cam regions. A sensor mounted on the frame controls the application of power of each station in turn as the corresponding station sector passes the datum for a duration determined by the length of one of the two cam regions as it passes the datum. It is a particularly important feature of the invention that each of the cam units is adjustable to vary the relative peripheral lengths of the associated first and second cam regions independently of all the other cam units. Thus a change in the timing setting for one station does not require any change in the settings for any of the other stations.

As a further advantage of the adjustable cam structure, each sector can be provided with an individually calibrated scale starting at a zero point adjacent one peripheral end of the associated station sector, extending peripherally therefrom in units calibrated directly in units of time. By providing a pointer on the end of the peripherally adjustable cam which moves along the calibrated scale, the timing period for each station can be directly set without requiring mental computations by the operator. An additional advantage of the calibrated scales on the various station sectors is that, as each scale passes the datum, an operator is provided with a direct visual indication of the time of operation remaining at that station. A further feature of the invention resides in the use of two motors to operate the timing unit, a continuously operating timing motor and an intermittently operated advance motor. The motors are connected to the station timer by a timing drive and an advance drive, respectively. Each drive is enabled to overrun the other when its associated motor is acting to drive the station timer more rapidly than the other motor. During operation the timing motor drives each station sector past the datum at timing speed during the portion of its traverse that power is being applied to the corresponding station. The advance motor drives the station timer at a relatively much faster speed during the other portion of traverse of each station sector past the datum in which power is not being applied to the corresponding station. Thus, the effect of the advance motor is to drive the station timer rapidly through each of the dead periods in which power is not being provided to the stations.

In addition to the station sectors, the station timer also includes a rest sector which is aligned with te datum at the conclusion of each complete revolution of the station timer. Disengaging structure incorporated in the timing drive disconnects the timing drive from the station timer when the rest sector is adjacent the datum so that the station timer can remain stationary in a condition of repose while the timing motor continues to turn. In this condition of repose, no power is being delivered to any of the power utilizing stations. At preselected times determined by a periodic timer driven by the timing motor, power is connected to the advance motor. The advance motor then moves the station timer out of its position of repose, thereby reengaging the timing drive and initiating a fresh cycle of operation of the station timer so that power will again be applied to each of the stations in turn for the preselected periods.

The foregoing and other advantages and features of the invention will be described more fully in the detailed description hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a fragmentary front view of a timing unit according to the preferred embodiment of the invention, showing hour, day, and station, rotary timers forming a part of the invention;

FIG. **2** is a cross-sectional view of the timing unit shown in FIG. **1** taken along the lines **2—2** therein;

FIG. **3** is a fragmentary view, on an enlarged scale, of a peripherally adjustable cam unit forming a part of the rotary station timer shown in FIG. **1**;

FIG. **3***a* is a cross-sectional view of a portion of the adjustable cam unit shown in FIG. **3** taken along the lines **3***a* —**3***a* therein;

FIG. **4** is a fragmentary view of the portion of the timing cam shown in FIG. **3** illustrating a reduction in peripheral length of a wall forming a part of the cam unit;

FIG. **5** is a view on an enlarged scale of two gears forming a part of the timing unit shown in FIG. **1** along the lines **5—5** therein, showing a cutout portion in one of the gears;

FIg. **6** is a fragmentary view on an enlarged scale illustrating a selecting pin forming a part of the hour timer shown in FIg. **1**, with the selecting pin shown in a selected position;

FIG. **7** is a view of the selecting pin shown in FIG. **6** but with the selecting pin in an unselected condition;

FIG. **8** is a cross-sectional view of an overrunning clutch forming a part of the timing unit shown in FIG. **1** taken along the lines **8—8** therein;

FIg. **9** is a cross-sectional view of a portion of the day rotary timer showing a star wheel associated therewith; and

FIG. **10** is a simplified representation of the electrical circuitry of the timing unit shown in FIG. **1**.

DETAILED DESCRIPTION

A timing unit according to the invention is utilized to deliver power to a plurality of power utilizing stations in cycles of operation commencing at preselected times with power being delivered to each station in turn during each cycle for periods which are individually preselected for each station. The timing unit may, for example, by utilized to control the operation of a plurality of lawn sprinklers in a domestic irrigation system. Using the unit a home owner can set the unit for automatic control of sprinklers at preselected days and hours within an endlessly repetitive two-week cycle with each of the sprinklers being operated in turn during each cycle for a period which is individually preselected to take into account the water needs of the particular lawn region covered by each sprinkler. Although the timing unit will be discussed with particular reference to controlling a lawn sprinkling system, it will be appreciated that the timing unit is not confined to such an application, but may be utilized for periodic timing control of many diverse applications such as control of illumination or for operating mechanisms or other devices not related to lawn sprinklers.

As shown in FIG. **10**, the timing unit is used to control application of electrical power to a plurality of stations I thorugh VII comprising electrically actuated lawn sprinkler valves. The timing unit includes a frame **2** (FIGS. **1** and **2**) having a vertical front face **4** on which are mounted a rotary day timer **6**, a rotary hour timer **8**, and a rotary station timer **10**. The station timer is divided peripherally into a plurality of sectors including a REST sector and a plurality of station sectors I through VII, each of which corresponds to one of the stations I through VII. The station timer is periodically caused to make a complete revolution in an anticlockwise direction to move the sectors successively past a fixed datum **12** on the frame.

A plurality of cam units, generally designated **14**, (FIG. **10**) are mounted on the station timer, one to each station sector. Each cam unit **14** is individually and selectively variable to divide the outer periphery of the associated station sector into a first cam region **16** defined by the presence of the cam and a second cam region **18** defined by the absence of the cam. The presence of the first and second cam regions **16** and **18** as each of the station sectors I through VII passes the datum **12** is detected by a sensor **20**. During the periods that the sensor **20** senses each of the second cam regions **18** passing the datum, power is supplied to the one of the valves I through VII corresponding to the particular one of the station sectors I thorugh VII currently passing the datum. During the traverse of each second cam region past the datum, the station timer is moving at a timing speed which is such that the time needed to traverse the second cam region is equal to the time preselected for operation of the corresponding station.

As the following station sector reaches the sensor **20**, the first cam region **16** on the following sector is sensed by the sensor. Thereupon the station timer **10** commences to rotate at an advance speed which is substantially faster than timing speed, until the following second cam region **18** is reached. At that time the station timer reverts to timing speed and power is applied to the corresponding station. From the foregoing description it will be understood that the second cam regions **18** control the duration of power application to each of their associated stations while the first cam regions **16** control rapid advance of the station timer between consecutive applications of power to succeeding stations, thereby minimizing dead or wasted time in travel between consecutive applications of power to the stations.

Driving of the station timer is effected through the operation of a continuously operation timing motor **22** (FIG. **2**) and an intermittently operated advance motor **24** which operates when power is applied to it. The station timer **10** is secured to one end of a shaft **26** rotatably mounted in the frame **2,** having an index gear **28** fixedly mounted on the shaft. The index gear **28** forms part of a timing drive train connecting the station timer **10** to the timing motor **22.** The timing drive train includes a continuously driven pinion **30** connected to the motor output shaft, which drives a first reduction gear **32** connected to the input of an overrunning clutch **34.** The overrunning clutch **34** drives an output shaft **36,** rotatably mounted in the frame **2,** to which is fixedly secured a drive gear **38** which meshingly engages the index gear **28** to turn the station timer at timing speed.

Similarly, an advance drive train is provided to connect the station timer with the advance motor **24.** The advance drive train includes a pinion **40** connected to the output shaft of the advance motor, which drives another reduction gear **42** secured to the input of another overrunning clutch **44.** The output of the second overrunning clutch **44** is connected to the previously mentioned shaft **26** on which the station timer is mounted.

The function of the overrunning clutches **34** and **44** is to enable whichever of the motors **22** and **24** is turning the station timer faster at any moment, to overrun the other motor. Thus, when the advance motor is not operating, the overrunning clutch **44** enables the timing motor to drive the station timer at timing speed while overrunning the advance motor. Conversely, when the advance motor **24** is operating, the overrunning clutch **34** enables the advance motor to drive the station timer at advance speed while overrunning the timing drive motor. Each of the overrunning clutches is of the construction shown in FIG. **8** comprising spaced concentric inner and outer hubs **43** and **44.** Each outer hub **44** is rotatably mounted on the associated one of the shafts **26** and **36** and fixedly secured to the associated one of the gears **32** and **42** while each inner hub **43** is fixedly mounted on the associated one of the shafts **26** and **36.** The interior of each outer hub **44** is serrated with ratchet teeth inclined for one direction of rotational motion. The exterior of each inner hub has mounted thereon a continuous peripheral stip of mat-like material **46** comprising a backing strip supporting a plurality of inclined stiff fibers extending into contact with the serrations **45.** In one direction of relative rotation between the inner and outer hubs, the fibers engage the serrations to couple the hubs together for driving motion, while in the opposite direction of relative rotation the fibers slide over the serrations to decouple the hubs. The fiber mat in the preferred embodiment comprises a material sold by 3-M Company of Minneapolis under the name FIBRE-TRAN. Other known forms of overruning clutch may, however, be used as desired.

When the sensor **20** senses the leading end of the REST sector to be adjacent the datum **12** at the conclusion of a revolution, rotation of the station timer **10** ceases and the station timer remains at REST until the next preselected time for operation as determined by the preselected settings on the day and hour timers.

To enable the index gear **28** to remain stationary when the station timer **10** is in its position of repose, the index gear is provided at one point in its periphery with a region **50** (FIG. **5**) in which its peripheral gear teeth are removed so that meshing engagement with the drive gear **38** ceases. The peripheral location of the cutout **50** is such that it is adjacent the drive gear **38** in non-meshing relation therewith when the leading end of the REST sector is adjacent the datum, as shown in FIG. **1.** To allow for relative radial displacement of the gears **28** and **38** into and out of meshing engagement, the shaft **36** has one of its ends mounted on a ball joint **52** seated in the frame **2** (FIG. **2**) and its other end received within a closed oval slot **54** aligned radially towards the index gear **28.** A biasing spring **56,** having one end rotatably hooked about the shaft **36** has its other end secured to the frame **2** to urge the gears **28** and **38** relatively towards each other.

Each of the adjustable cam units **14** on the station timer is of the type disclosed in the patent application of Robert Costa et al. for a "Camming System Including A Flexible Cam of Adjustable Peripheral Length" being filed concurrently with the present application and assigned to the same assignee. Relevant portions of the disclosure of the Costa application are incoporated herein by reference. Briefly described, the station timer **10** has an opening **60** (FIG. **3***a*) extending completely around its peripheral edge, into which the previously mentioned sensor **20** projects. Each of the cam units **14** includes an elongated guide track constituted by two opposed, aligned grooves **62** formed in the station timer on opposite sides of the opening **60.** The grooves **62** slidably receive an elongate flexible wall **64** secured at its leading end to a hub **66.** The hub **66** is positioned adjacent the leading end of the particular station sector with which it is associated and rotates about an axis parallel to the axis of rotation of the station timer. A projecting knob on the hub can be turned to wind the wall **64** onto and off the hub to adjust the peripheral length to which the wall **64** extends along the guide track. As disclosed more fully in the aforementioned Costa application, the hub **66** is mounted on an axle and means is provided for securing the hub in any selected position relative to the axle to maintain a preselected setting of the wall along the guide track.

The portion of the wall between the hub and the free or trailing end of the wall constitutes the first cam region **16** while the remaining portion of the periphery of the station sector between the trailing end of the wall **64** and the trailing end of the sector constitutes the second cam region **18.** The previously mentioned sensor **20** constitutes a pivoted finger having a free end which is spring biased radially against an outer surface of the wall **64** exposed to the sensor, in alignment with the datum. During the first part of motion of a station sector past the finger, when the finger is riding on the outer surface of the first cam region, the finger is in a relatively raised condition in which it operates an associated master microswitch **68** (FIG. **1**) thereby causing the advance motor to drive the station timer through the first cam region at the relatively fast, advance speed. When the end of the finger drops off the trailing end of the wall **64** as the first cam region moves past the datum, the finger moves through a radial distance at least equal to the thickness of the cam wall to a relatively lowered position in which power is removed from the advance motor so that the station timer is driven through the second cam region at timing speed. It is for the duration that second cam region is moving past the datum as sensed by the finger **20** that power is applied to the associated sprinkler valve, as will be described.

The length of the wall **64** along the guide track determines the distance between the end of the wall and the trailing end of the sector constituting the second cam region thus providing a control of the duration for which power is applied to the corresponding station. The shorter the first cam region, the longer the second cam region will and hence, the longer the period to which power is applied to the corresponding sprinkler valve. Knowing the timing speed, it is possible to calibrate each station sector in terms of time of traverse. For example, if it takes one hour for a complete station sector to move past the datum at timing speed, then with the wall **64** fully wound onto the hub so that its trailing end is as closely adjacent to the leading end of the sector as possible, the second cam region will constitute effectively the entire length of the guide track and sprinkling will last for 1 hour in that position of adjustment. On the other hand, if the wall is unwound so that its trailing end is at the extreme trailing end of the guide track, there will be no second cam region and no application of power to whichever sprinkler corresponds to that sector. Instead, the station sector will move past the datum at advance speed for the entire sector. Between these two extreme positions, the length of the guide track can be provided with a calibrated scale in terms of time, from zero time at the trailing end of the guide track to maximum time at its leading end, as shown in FIG. **3**. An indicating pointer **70** carried by the trailing end of the wall **64** registers against the calibrated scale to indicate the sprinkling time set for the particular station sector.

It wil be appreciated that the structure of the cam unit **14** enables the sprinkler setting for any particular station to be selectively and individually adjusted without requiring any change in the settings for any of the other stations. Thus, there is no problem of cumulative settings requiring resetting of each of the downstream stations as is known with certain prior devices. In addition, because each sector has an individual time scale calibrated from zero to maximum time, each sprinkling time can be directly set by observing the position of the indicator pointer **70** against the scale so that there is no need for the operator to make mental additions or substractions in setting the sprinkling times. Another advantage of the calibrated scale is that by watching it pass the datum, a direct time indication of sprinkling time to go at that station is provided, again without requiring any mental calculations. Moreover, each cam can be easily adjusted without need for special tools such as screwdrivers or the like by simple turning of the projecting knob on each hub **66.** Further, the cam units, because they are mounted within the body of the station timer **10,** are not exposed in a vulnerable position like the timing clips that have been used on some prior devices.

In the preceding description of the cam unit, it has been assumed for ease of discussion that the first and second cam regions collectively constitute the total peripheral length of the station sector with which they are associated. In practice, as shown in FIG. **3,** because of mechanical limitations imposed by the thickness of the cam wall **64** and by the extreme limits to which it can be extended and wound up, the extreme positions of the calibrated scale do not extend completely to the leading and trailing ends of each sector. However, the extreme trailing end of one guide track is so close to the leading end of the next following cam wall, which projects somewhat in advance of the leading end of the associated sector as can be seen in FIG. **3**, that the operation is as described for all practical purposes.

It will be also understood that the provision of the rapid advance speed by the advance motor avoids wasted time in traversing the first cam region of each sector in which no application of power to the sprinkler valves is occurring. If it was necessary to traverse between sprinkling times at the relatively slower timing speed employed during sprinkling, it would not be possible to control as many sprinkling stations within a particular timing period.

The REST sector, along its periphery has a curved continuous wall **78** (FIGS. **1** & **2**) having an outer surface exposed to the sensor, which is at the same radial distance from the axis of rotation of the station timer **10** as the outer surface of each of the first cam regions **16.** Thus, when the REST sector is contacting the finger **20,** the finger is in the raised condition connecting the advance motor to the input of the master switch **68.**

It is also necessary to provide a selector system to select each of the sprinkler valves for connection of power thereto within the time that its corresponding station sector is passing the datum for the duration that the second cam region on the corresponding station sector is passing beneath the sensor. Such selection system includes a rotary selector switch **80** (FIG. **10**) having a central shaft **82** fixedly secured to and driven directly by the shaft **26** of the station timer. Fixedly secured to the shaft **82** are first and second, generally circular, switch wafers **84** and **86,** respectively, not electrically connected to each other.

In continuous sliding contact with the first wafer **84,** is a stationary electrical connection **88** which supplies power to the first wafer whenever one of the second cam regions **18** is passing the sensor **20.** The first wafer **84** is provided with a projecting segmental wiper portion **90** which is moved successively past a plurality of fixed station connections **91** through **97** connected to the stations I through VII, respectively to make electrical contact with each of the station connections in turn. The wiper portion **90** includes a leading end **100** which is angularly positioned in relation to the station timer **10** in such relation that the leading end **100** reaches each of the station connections slightly in advance of the arrival of the leading end of the corresponding one of the station sectors at the datum **12.** This slight advance relationship ensures that a path for power to the associated station always exists by the time that the sensor **20** commences to sense the second cam region, even in the condition when the second cam region constitutes the entire length of the guide track.

The wiper portion **90** also includes a trailing end **102** which is angularly positioned in such relation to the station timer **10** that the extreme trailing end of each second cam region passes the datum 12 at the same time that the trailing end 102 of the wiper portion ceases to make electrical contact with the corresponding one of the station connections 91 through 97. When the REST sector is adjacent the datum, the wiper portion 90 on the first wafer is out of contact with any of the station connections 91 through 97.

The function of the second switch wafer 86 will be described hereinafter in the description of operation of the system.

Initiation of each cycle of operation of the station timer at preselected intervals is effected by a periodic timing system which includes the previously mentioned day and hour timers 6 and 8. The hour timer 8 is continuously driven by the timing motor 22 via a reduction gear train which is so arranged in relation to the speed of the timing motor that the hour timer 8 makes one complete revolution in 24 hours. The reduction gear train includes an intermediate gear 103 having a first toothed periphery 104 (FIG. 2) engaging the previously mentioned gear 32 and a second toothed periphery 106, of relatively smaller diameter. The gear 103 is mounted on a shaft 108 supported for rotation by the frame 2 with the periphery 106 meshingly engaging a gear 110 secured to the input of an overrunning clutch 112 of the same construction as the clutches 34 and 36. The output of the overrunning clutch 112 is drivingly secured to a shaft 114 rotatably mounted in the housing 2 and supporting the hour timer 8 at one of its extremities. The overrunning clutch 112 is to enable the hour timer to be reset to a particular time without requiring movement of the gears in the reduction train to the timing motor.

At one point on its periphery, the hour timer is provided with a projection 116 (FIG. 1) which engages one of a plurality of pins 118 positioned in cage-like disposition around the periphery of the day timer 6 to advance the day timer by a one day interval during each complete revolution of the 24 hour timer. To ensure that the day timer moves through a complete day interval, a star wheel 120 (FIG. 9) is fixedly secured to a shaft 122 rotatably supported in the frame 2, on which the day timer 6 is mounted. The star wheel 120 is engaged by a spring detent 124 secured to the frame, which has a free end of generally V configuration engaging the indentations of the star wheel 120. Each star wheel indentation corresponds to a one-day interval and the self centering action exerted by the spring detent 124 ensures that the day timer turns through a complete one day interval each time the projection 116 on the hour timer advances one of the pins 118.

The day and hour timers each carry selecting pins controlling the operation of two, day and hour microswitches which are connected in series to provide a path for an initiatory application of power to advance the station timer from the REST position at preselected intervals. More specifically, the hour timer 8 (FIGS. 1 and 10) is provided with twenty-four selecting pins 130 spaced at equal intervals about its periphery, each corresponding to an indicated one of the 24 hours of the day. Each selecting pin 130 (FIGS. 6 and 7) has a head portion 132 on the outwardly facing side of the hour timer and a shank 134, of relatively reduced diameter compared to the head portion, extending through an opening in the timer. On the opposite side of the opening are molded detent portions 136 on the carrier resiliently biased inwardly into gripping but sliding contact with the shank 134. Intermediate the ends of shank 134 is a neck portion 138 of further reduced diameter. In an unselected position of the pin (FIG. 7), the detent portions 136 are snapped into engagement with the neck portion 138 of the shank so that the remote end thereof is held away from a pivoted finger 140 connected to an hour microswitch 142 mounted on the frame 2 adjacent the upper end of the hour timer. By pushing the head of the selector pin 130 inwardly to a selected position (FIG. 6), the detent portions 136 can be forced apart by the shank so that its remote end is moved into overlapping relation to the finger 140. The remote end of the finger 140 is bent at a downward inclination into the path of travel of the selected pins and is biased downwardly. Movement of a selected one of the pins 130 against the end of the finger 140 raises it, thereby closing the contacts of the microswitch 142.

Similar day selector pins 150 are provided at equally spaced intervals about the periphery of the day timer 6. The number of day selector pins 150 is equal to the total number of days in the repetitive cycle of operation of the unit and each pin is positioned adjacent an indicated day of the week marked on the timer. Each of the selector pins 150 is of identical construction to the previously described hour selector pins 130. A day mircoswitch 152 positioned adjacent the lower end of the day timer has an upwardly biased pivoted finger 154 with an upwardly inclined remote end, which is depressed each time a selected one of the day pins 150 passes the finger, thereby closing the contacts of the day microswitch.

Operation of the Timing Unit

The operation of the timing unit is best explained with reference to the schematic circuit diagram shown in FIG. 10. The operation will be considered as starting at a time when the cam units 14 have been preset for the desired sprinkling times at the various stations and the appropriate pins 130 and 150 have been preselected on the hour and day timers so that sprinkling will occur on selected days at selected times of the day.

Mains electrical power from an electrical source E at 115 volts AC is provided to the primary of a transformer 156 and operating power for the timing unit at 24 volts AC is derived from the secondary of the transformer. In the following explanation the lower end of the transformer secondary in FIG. 10 will be considered the power side and the upper side the common side connected to a common line 158. Power from the power side of the secondary of the transformer 156 is connected via a conventional, normally closed circuit breaker 160 to one side of the timing motor 22 which is connected on its other side to the common line, thus operating the timing motor continuously.

The output of the circuit breaker 160 is also connected to the input side of a manually operated slide switch 162. During automatic operation of the timing unit the slide switch 162 is closed to connect the power to the day microswitch 152. The day microswitch 152 and the hour microswitch 140 are connected in series via lines 164 and 168 to a switch input terminal 170 forming a part of the previously mentioned master switch 68. When the day timer has moved to bring a preselected day pin into position contacting the finger 150 of the day microswitch 152, the latter will be closed. However a series connection to the terminal 170 will not be completed until the hour timer has also reached a position in which one of the preselected hour pins **130** has moved the finger **140** to close the terminals of the hour microswitch **42.** At this timer power is connected via the slide switch **162** and the day and hour microswitches to the input terminal **170** of the master switch **68.**

With the station timer **10** in the RESt position, the sensor **20** is in its raised condition connecting the switch input **170** to a first switch output terminal **172** connected to the positive side of the advance motor **24** which is connected on its down side to the common line **158.** An initiatory application of power, through the closed day and hour microswitches and the switch input **170** connected to the first switch output **172,** to the advance motor causes it to start rotating the station timer at advance speed in an anticlockwise direction. This motion moves the index gear **28** so that the cutout region **50** therein passes beyond the adjacent gear **38** and the timing drive is reengaged. However, the first overrunning clutch **34** enables the advance motor to overrun the timing motor so that the station timer continues to rotate at the advance speed until the first cam region of station sector I reaches the sensor **20.**

To maintain a continuous power connection to the switch input terminal **170** for a complete revolution of the station timer, even if one or other of the day or hour microswitches should open during the time of rotation thereby terminating the initiating application of power, an electrical circuit is provided through the second switch wafer **86.** A fixed electrical connection **180** slidably contacting the second wafer **86,** is connected via a line **182** to the output side of the switch **162.** Another stationary electrical connection **184** slidably contacting the second switch wafer **86** is connected via a line **186** to the switch input **170** so that a continuous power connection to the switch input is maintained via the second switch wafer during rotation of the station timer. The electrical connection through the second switch wafer **86** is broken when the station timer returns to its REST condition with the leading end of the REST sector aligned with the datum, by a cutout region **188** in the second wafer switch.

When the first cam region **16** of the station sector I reaches the datum, the sensor **20** continues to remain in the raised condition because the exterior surface of the wall **64** is on the same radial level as the REST sector so that the station timer continues to move at the advance rate through the extend of the first cam region **16.** In advance of this motion the wiper portion **90** on the first wafer switch **84** establishes electrical contact with the first station connection **91.**

When the first cam region **16** passes beyond the sensor **20,** the latter moves downwardly by at least the thickness of the cam wall **64** to connect the switch input **170** to a second **190** of the master switch **68.** The switch second output **196** is connected via a line **192** to the sliding connection **88** to the first switch wafer **84** which is already in contact through the wiper portion **90** with the first station connection **91.** As a result, power is connected to the first one of the stations. Concurrently, the first switch output **172** is disconnected from the switch input, thereby disconnecting the advance motor from power so that the station timer is now driven via the timing drive by the timing motor **22** at timing speed. The second overrunning clutch **44** enables the timing drive to overrun the advance motor which is not turning. For the duration of the second cam region, the station timer is moved at timing speed to continue the application of power to the first station for the preselected time determined by the length of the second cam region **18** in the manner previously described.

The foregoing process is repeated as each of the succeeding station sectors reaches and passes beneath the datum until power has been applied to each of the sprinkler valves I through VII in turn for the duration preselected for each.

When the leading end of the REST sector returns to the datum, the cutout portion **50** on the index gear will again be adjacent the gear **38** terminating meshing relation between them so that the station timer is no longer driven by the timing drive. At the same time, the cutout region **188** will break the electrical connection to the stationary connection **184** thereby terminating the power connection for the rapid advance motor **24** (assuming that one or other of the day and hour switches has opened by this time). As a result, the station timer ceases to turn and will remain at rest until the next occasion in which both the day and the hour switches close to complete a series connection to the master switch input for another initiatory application of power.

In controlling a sprinkler system, it will also be necessary to operate an electrically controlled master valve during operation of each of the sprinkler valves. For this purpose, a line is provided connecting the output side of the hour microswitch **140** to the master valve. Thus, at the preselected hour and day periods when both microswitches **140** and **152** are closed, power will be connected through the line **200** to the master valve. In addition, in a sprinkler system, it will also be necessary to provide a power connection to a pump during the period that the sprinklers are being operated. For this purpose, a line is provided connecting the switch input terminal **170** via a relay coil **204** to the common line **158.** During the period that power is supplied to the switch input terminal **170,** current through the relay coil **204** will close a pump start relay **206** to operate the pump.

Although the invention has been described with reference to a preferred embodiment, it will be understood by those skilled in the art that many additions, substitution, modifications, and other changes may be made which will fall within the spirit of the invention herein disclosed and claimed.

I claim:

1. A timing unit for connecting power sequentially to each of a number of stations, comprising:

a frame;

a station timer rotationally mounted on said frame, said station timer being divided peripherally into sectors including a number of station sectors each corresponding to one of the stations;

a plurality of individually adjustable cam means each mounted on one of said station sectors, each said cam means dividing the peripheral length of the associated said station sector into first and second cam regions which are selectively variable in relative length;

drive means connected to said frame for rotating said station timer at a timing speed and at an advance speed relatively faster than said timing speed to move said sectors successively past a fixed datum on said frame;

sensing means mounted on said frame for sensing said first and second cam regions as each said station sector passes said datum, said sensing means being connected with said drive means to cause rotation of said station timer at timing speed whenever on of said second cam regions is sensed by said sensing means and at advance speed whenever one of said first cam regions is sensed by said sensing means; and

selector means connected with said station timer and said sensing means for connecting power to each station while the corresponding one of said station sectors is passing said datum for the duration that said second cam region on said corresponding station sector is sensed by said sensing means.

2. A timing unit as defined in claim **1**, wherein each said cam means includes

an elongate guide track extending along the periphery of the associated one of said station sectors,

an elongate flexible wall supported by said guide track extending at least partially therealong from one peripheral end of said guide track, said sector thereby having its periphery divided into two parts where said wall is present and absent, said two parts constituting said first and second cam regions; and

adjusting means for selectively varying the extent to which said wall extends along the peripheral length of said track.

3. A timing unit as defined in claim **2**, wherein

said guide track is curved to support said wall in a curve substantially concentric with the axis of rotation of said station timer.

4. A timing unit as defined in claim **2**, wherein each said adjusting means further includes:

an axle mounted on said station timer adjacent said one peripheral end of the associated said guide track;

a hub mounted on said axle for rotation thereabout, said wall at one peripheral end thereof being fixedly connected to said hub to enable said wall to be wound and unwound around said hub, said wall having portions movably engaging said track whereby said track guides and supports said wall; and

means for securing said hub against rotation relative said axle in any selected position of said wall along said track.

5. A timing unit as defined in claim **2**, wherein said said cam means further includes

a calibrated scale on said station timer extending along said guide track; and

indicating means on said wall at an end thereof remote from said one peripheral end of said guide track, said indicating means cooperating with said calibrated scale to provide an indication of the extent to which said wall extends along the peripheral length of said guide track.

6. A timing unit as defined in claim **1**, further including,

a peripherally extending rest sector in said station timer,

disengaging means connected with said drive means for terminating rotation of said station timer when said rest sector is in a predetermined position of proximity to said datum, said drive means thereafter reengaging driving connection with said station timer for rotation thereof through a complete revolution upon connection to said driving means of an initiatory application of power; and

periodic means for connecting said driving means to an initiatory application of power at preselected times.

7. A timing unit for connecting power sequentially to each of a number of stations, comprising:

a frame;

a station timer rotationally mounted on said frame, said station timer being divided peripherally into sectors including a number of station sectors each corresponding to one of the stations;

a continuously operating timing motor connected to the frame;

an advance motor mounted on said frame operable intermittently when connected to power.

timing drive means and advance drive means for connecting said timing and advance motors to the station timer to rotate said sectors in the same direction past a fixed datum on said frame at a timing speed and a relatively faster advance speed, respectively, said timing and advance drive means enabling whichever of said motors is driving said station timer at a relatively faster speed at any moment to overrun the other of said motors;

a plurality of individually adjustable cam means each mounted on one of said station sectors, each said cam means dividing the peripheral length of the associated said station sector into first and second cam regions which are selectively variable in relative length;

sensing means mounted on said frame for sensing said first and second cam regions as each said station sector passes said datum;

selector means connected with said station timer and said sensing means for connecting power to each station while the corresponding one of said station sectors is passing said datum for the duration that said second cam region on said corresponding station sector is sensed by said sensing means; and

switch means connected to said sensing means for connecting power to said advance motor whenever any of said first cam regions is sensed by said sensing means.

8. A timing unit as defined in claim **7**, further including

a peripherally extending rest sector on said station timer, said sensing means sensing said rest sector when said rest sector is adjacent said datum,

a switch input to said switch means, said switch means connecting said switch input to said advance motor whenever said sensing means senses said rest sector or any of said first cam means,

disengaging means for disengaging said timing drive means from said station timer when said rest sector is in a predetermined position of proximity to said datum thereby enabling said station timer to remain in a stationary position while said timing motor continues to operate;

periodic means for selectively applying power to said switch input at preselected times.

9. A timing unit as defined in claim **8**, wherein connection of power to said switch input by said periodic means at a time when said station timer is in the stationary position causes said advance motor to advance said station timer sufficiently to advance a first one of said station sectors to said datum, the timing unit further including,

means for maintaining a continuous power connection to said switch input while any of said station sectors is passing said datum thereby providing a power path to said advance motor via said switch means during sensing of each of said first cam regions.

10. A timing unit as defined in claim **9**, wherein said periodic timing means is driven by said continuously operating timing motor to connect power to said switch input at said preselected times.

11. A timing unit as defined in claim **10**, wherein said periodic timing means further includes:

an hour timer rotatably mounted on said frame driven by said timing motor to complete one revolution in a predetermined number of hours;

a plurality, individually selectable, hour selecting means mounted at equal intervals on said hour timer;

a rotary day timer rotably mounted on said frame, said day timer being equally divided into a predetermined number of day sectors and being advanced through one day sector every 24 hours by said hour timer,

a number of day selector means equal to the predetermined number of day sectors mounted on said day timer at equally spaced intervals thereon; and

a day switch and an hour switch mounted on said frame, said switches being closed by individually selected ones of said day and hour selecting means, respectively, upon movement thereof into registration with said switches, said day and hour switches being connected in series to connect power to said switch input at preselected day and hour settings.

12. A timing unit as defined in claim **11**, wherein said hour timer is driven through a drive train by said timing motor and includes a projection at one peripheral point on said hour timer, said day timer including engagement portions spaced at intervals about the periphery thereof, said engagement portions being contacted one at a time by said projection on said hour timer during each complete revolution thereof to advance said day timer by one of said day sectors.

13. A timing unit as defined in claim **7**, wherein each said cam means includes

an elongate guide track extending along the periphery of the associated one of said sectors,

a flexible wall supported by said guide track extending at least partially therealong from one peripheral end of said guide track, said sector thereby having its periphery divided into two parts where said wall is present and absent, respectively, said parts constituting said first and second cam regions, respectively; and

adjusting means for selectively varying the extent to which said wall extends along the peripheral length of said track.

14. A timing unit as defined in claim **13**, wherein said guide track is curved to support said wall in a curve substantially concentric with the axis of rotation of said station timer.

15. A timing unit as defined in claim **13**, wherein each said adjusting means further includes:

an axle mounted on said station timer adjacent said one peripheral end of the associated said guide track;

a generally annular hub mounted on said axle for rotation thereabout, said wall at one peripheral end thereof being fixedly connected to said hub to enable said wall to be wound and unwound around said hub, said wall having portions slidably engaging said track whereby said track guides and supports said wall; and

means for securing said hub against rotation relative said axle in any selected position of said wall along said track.

16. A timing unit as defined in claim **13**, wherein said sensing means includes:

a finger biased radially towards said station timer in alignment with said datum, said finger being held in a first position by each said wall during movement thereof past said datum in underlying, sliding contact to said finger, said finger moving radially inward to a second position as each said wall passes beyond said finger, said finger being connected to said switch means to connect power to said advance motor in one of said positions of said finger and to disconnect power from said advance motor in the other of said positions.

17. A timing unit as defined in claim **7**, wherein said selector means comprises a rotary switch having:

a wiper arm rotated by said station timer;

a plurality of switch connections positioned to be sequentially contacted by said wiper arm during rotation thereof, each said switch connection being connected to an associated one of the stations, the angular relationship between said wiper arm and said station timer being such that each station connection is contacted by the wiper arm during the period that the corresponding one of said station sectors is passing said datum, and

means for connecting said wiper arm to power during the period that the one of said second cam regions associated with said corresponding station sector is being sensed by said sensing means.

18. A timing unit as defined in claim **17**, wherein said switch means includes a first switch output connected to said advance motor and wherein said means for connecting said wiper arm to power includes:

a second switch output of said switch means connected to said wiper arm, said switch means connecting power to said second switch output whenever any of said second cam regions is sensed by said sensing means.

19. A timing unit as defined in claim **7**, further including:

an overrunning clutch interposed in said timing drive means to enable said advance motor to overrun said timing motor during periods when said advance motor is driving said station timer.

20. A timing unit as defined in claim **7**, further including:

an overrunning clutch interposed in said advance drive means to enable said timing motor to overrun said advance motor during periods when said advance motor is disconnected from power.

21. A timing unit as defined in claim **8**, wherein said timing drive means includes:

a first toothed gear drivingly connected with said station timer for rotating the same;

a second toothed gear drivingly connected with said timing motor, said toothed gears meshingly engaging each other;

and wherein said disengaging means includes:

a cutout region in said first toothed gear at one peripheral location thereon, said cutout region enabling said second gear to continue to rotate without turning said first gear, said peripheral cutout portion of said first gear being positioned such that said gears are in a non-meshing relation when said rest sector is in the predetermined position of proximity to the datum; and

means supporting said gears for radial motion relative to each other into an out of meshing engagement.

22. A timing unit for sequentially connecting power to each of a number of stations, comprising:

a frame;

a station timer rotationally mounted on said frame, said station timer being divided peripherally into sectors including a rest sector and a number of station sectors each corresponding to one of the stations;

a continuously operating timing motor mounted on said frame;

an advance motor mounted on said frame intermittently operable when connected to power;

timing drive means and advance drive means for connecting said timing and advance motors to said station timer to rotate said sectors in the same direction past a fixed datum on said frame at a timing speed and a relatively faster advance speed, respectively, said timing and advance drive means enabling whichever of said motors is driving said station timer at a relatively faster speed at any moment to overrun the other of said motors,

a plurality of individually adjustable cam means each mounted on one of said station sectors, each said cam means being separately and individually adjustable to divide the outer peripheral length of the associated one of said station sectors into first and second cam regions;

sensing means mounted on said frame for sensing said first and second cam regions as each said station sector passes said datum and for sensing said rest sector when said rest sector is adjacent said datum,

a rotary selector switch having a switch wiper rotatably driven by said station timer and a plurality of selector connections each connected to one of the stations, each station connection being contacted by said wiper while the corresponding one of said station sectors is passing said datum;

a master switch having a switch input and first and second switch outputs, said first and second switch outputs being connected to said advance motor and to said wiper arm, respectively, said sensing means causing said switch input to be connected to said first output when said rest sector and any of said first cam regions is sensed by said sensing means and causing said switch input to be connected to said second switch output when any of said second cam regions is sensed by said sensing means;

disengaging means for disengaging said timing drive means from said station timer while said rest sector is adjacent said datum; and

periodic means mounted on said frame for connecting power to said switch input at preselected times.

23. A timing unit as described in claim **22**, further including,

power connection means for maintaining a continuous power connection to said switch input while any of said station sectors is passing said datum.

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