Feb. 16, 1971 R. W. KEARNS 3,564,374

INTERMITTENT CONTROL DEVICE

Original Filed Dec. 1, 1964 3 Sheets-Sheet 1

Fig. 1.

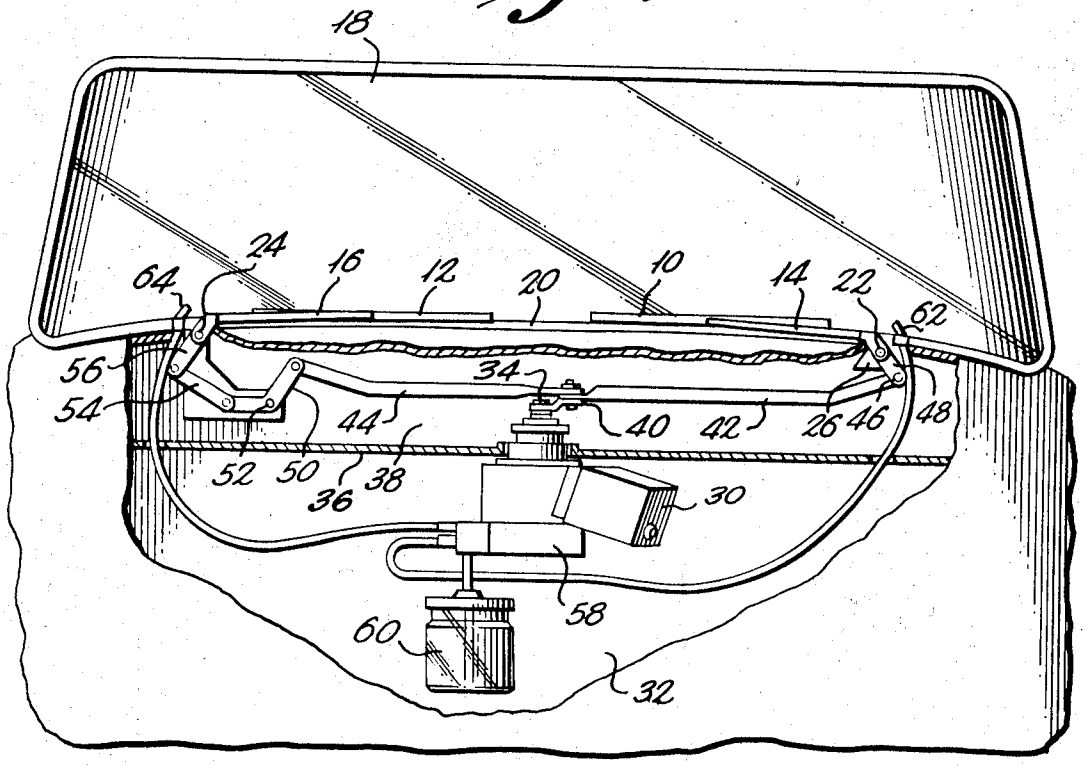
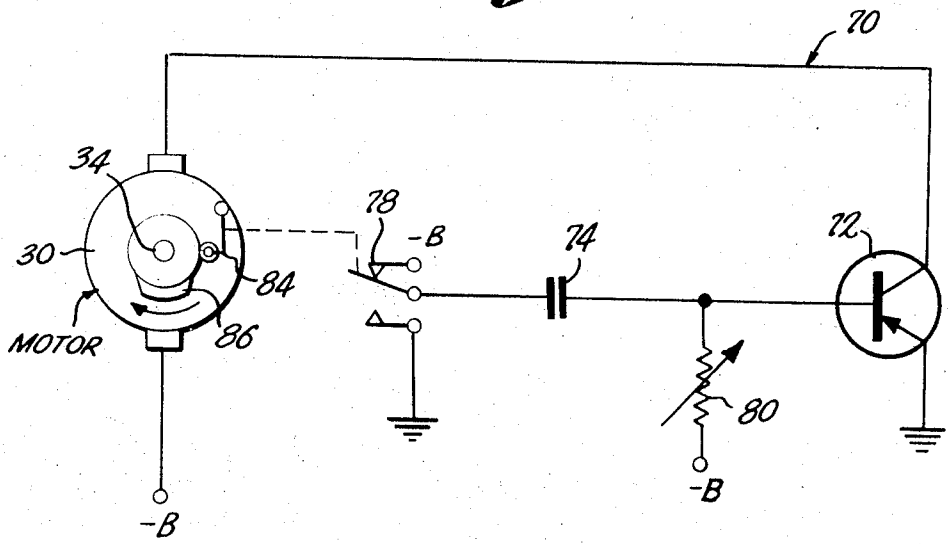


Fig. 2.



INVENTOR

Robert W. Kearns

BY Lane, Aitken, Dunner & Ziems

ATTORNEYS

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INTERMITTENT CONTROL DEVICE

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Fig. 3.

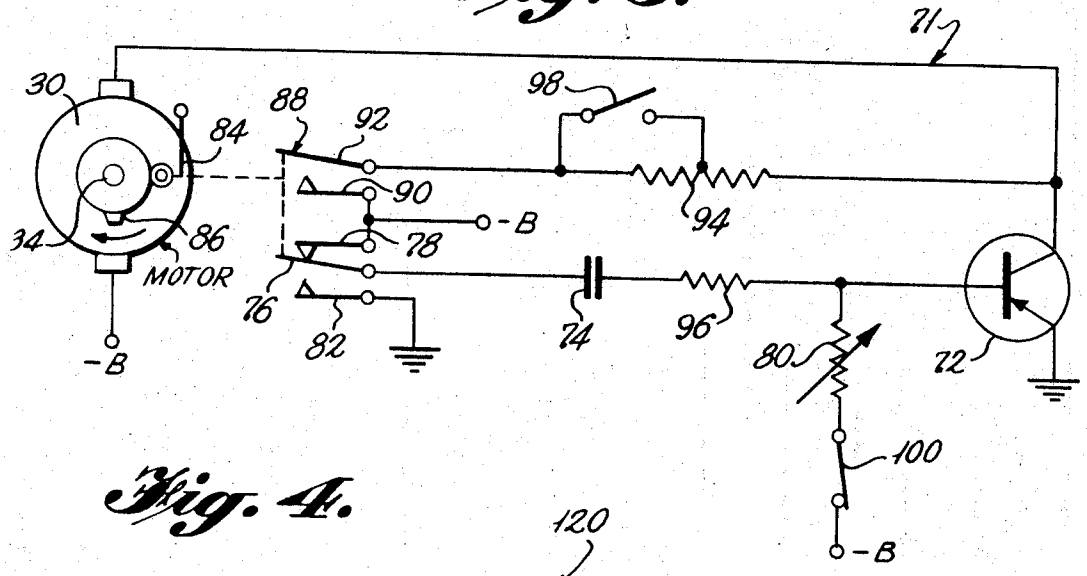
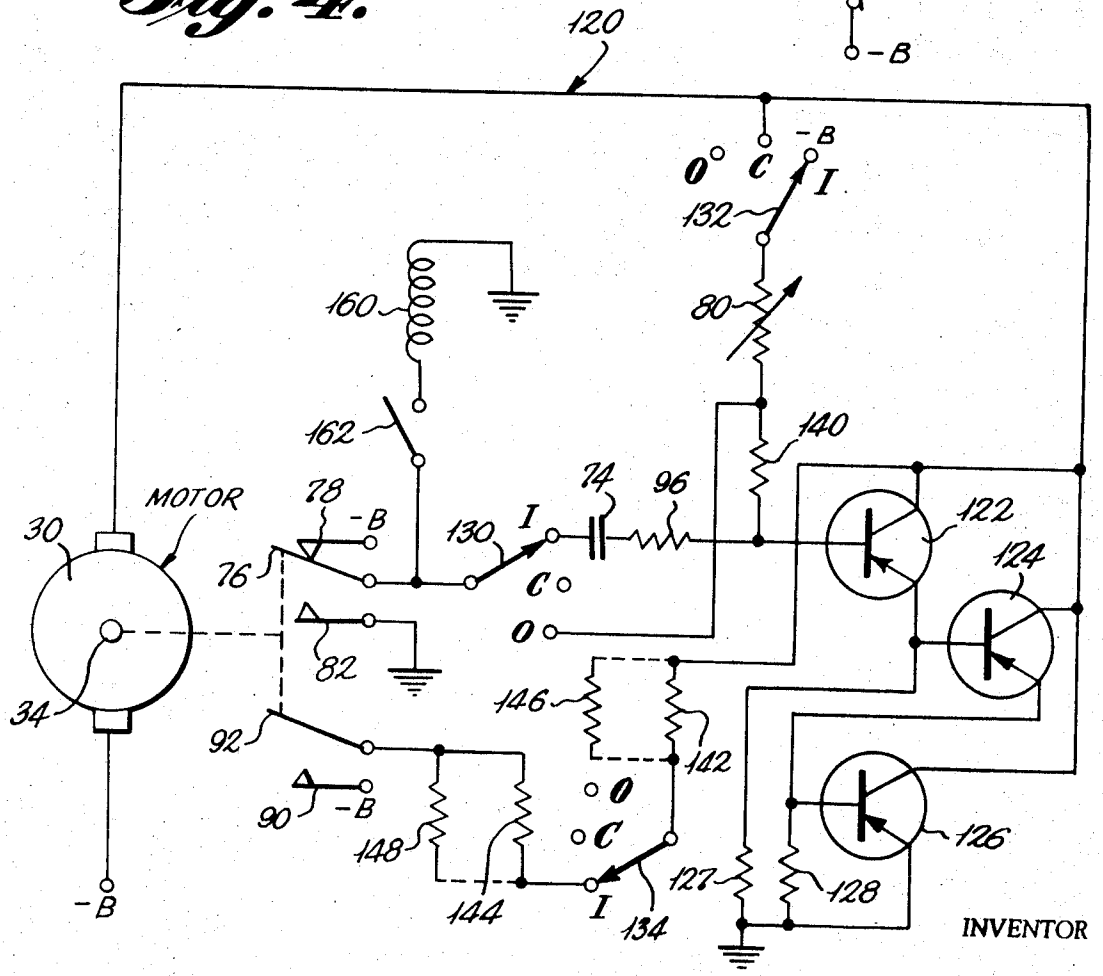


Fig. 4.



INVENTOR

Robert W. Kearns

BY Lane, Aitken, Dunner & Ziems

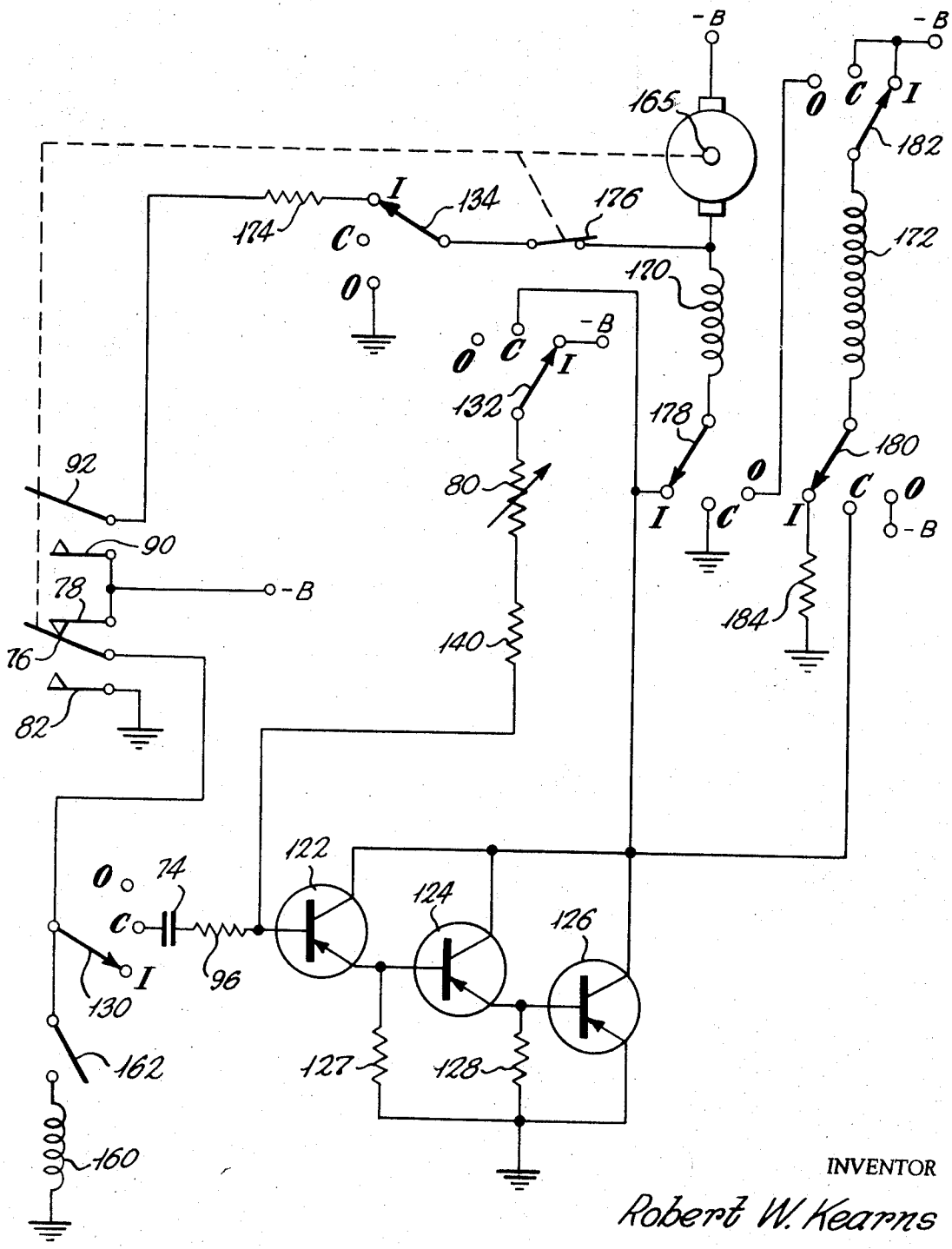
ATTORNEYS

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Fig. 5.



INVENTOR

Robert W. Kearns

BY Lane, Aitken, Dunner & Ziems

ATTORNEYS

United States Patent Office 3,564,374
Patented Feb. 16, 1971

3,564,374

INTERMITTENT CONTROL DEVICE

Robert W. Kearns, Detroit, Mich., assignor, by mesne assignments, to Tann Company, Detroit, Mich., a partnership of Michigan

Original application Dec. 1, 1964, Ser. No. 414,973, now Patent No. 3,351,836, dated Nov. 17, 1967. Divided and this application Sept. 21, 1967, Ser. No. 669,616
The portion of the term of the patent subsequent to Nov. 7, 1984, has been disclaimed
Int. Cl. H02p 7/06
U.S. Cl. 318—443 18 Claims

ABSTRACT OF THE DISCLOSURE

A windshield wiper control which operates the wiper blades continuously or intermittently with a dwell period between each wiping cycle. In the intermittent operation the wiper blades are responsive to the condition of the windshield. Transistors are provided for controlling the intermittent operation and also for controlling the continuous mode of operation. In the intermittent mode of operation, the time interval of the dwell periods can be varied between zero and a predetermined maximum time interval so that when the dwell periods are set at zero the wiper blades operate continuously. The length of time of the dwell periods is determined by a capacitive timing control in which the capacitor is charged by the battery of the automotive vehicle and thereafter is connected in an RC circuit in a manner to apply to the resistance of the RC circuit a potential greater than the battery voltage.

CROSS REFERENCES TO RELATED APPLICATION

This application is a division of my co-pending application Ser. No. 414,973 filed Dec. 1, 1964, now Pat. No. 3,351,836 and entitled Windshield Wiper System With Intermittent Operation.

BACKGROUND OF THE INVENTION

Under certain conditions, such as light rain or splash-back produced by other vehicles on wet roads, the condition of the windshield is often in what may be termed a wet-dry condition. Continuous windshield wiper operation with such a windshield condition may cause smearing to obscure the vision of the driver. The wiper element also may be inadequately lubricated, causing undue wear on the wiper blade. To overcome these problems, it is desirable to provide an intermittent operation in which the wiper dwells for an interval of time after a wiping operation and then automatically begins another cycle of operation.

During these intermittent dwell periods, the windstream against the windshield due to vehicle motion can be employed advantageously to dry and dissipate the thin film of vision obscuring moisture which is created by wiper operation over a wet-dry windshield. The intermittent operation also affords relief from monotony of wiper motion and prolongs the life of the wiper blades, the wiper motor and the wiper linkages, not only beacuse of the intermittent rather than constant cycling, but also because the accumulation of moisture during dwell periods acts as a lubricant for the wipers during the next cycle of operation. The increased lubrication due to moisture accumulation on the windshield during dwell periods, plus the advantage of being able to run the wipers at a constant prescribed velocity, eliminates the tendency for the wipers to chatter. This definitely improves the quality of lesser wiping strokes and also prolongs the life of the rubber because it is not subjected to the wet-dry drag

which normally acts to deteriorate the wiping lip and deposit rubber on the tacky glass surface.

However, when the water on the windshield increases due to increased rain, or wheel spray from a vehicle which is being passed, it is very desirable to sense this change in condition of the windshield, automatically switch the wiper system to continuous operation while this condition prevails and automatically switch back to intermitten operation when the condition no longer prevails. The patent to Ziegler 3,148,399, discloses a system of this general type which utilizes a thermal responsive switch element for disconnecting the motor from its power source after an indeterminate number of wiping cycles. However, operation of this wiper system is erratic and unreliable. The patent to Oishel et al. 3,110,056, discloses a cam actuated switching arrangement for causing a windshield wiper system to dwell at the end of each wiping cycle and provides an additional control responsive to accelration of the vehicle for changing the intermittent operation to continuous operation. The latter control includes a switch mounted for actuation by the accelerator pedal of the vehicle or means responsive to the engine intake manifold vacuum. Therefore it is apparent that this arrangement is not responsive to the condition of the windshield.

I have found that an intermittent windshield wiper system which is truly responsive to the condition of the windshield can be provided by utilizing the drag encountered by the wiper blades moving over the windshield to determine whether the wiper blades are stopped for a dwell period at the end of each cycle or whether the dwell period is skipped to provide continuous operation. In accordance with one embodiment involving an electric windshield wiper system for automotive vehicles, the electric motor is de-energized at a predetermined point near the end of each wiping cycle to initiate a decelerating period during which the motor continues to rotate through a small angle due to the momentum of the system. During the decelerating period, the drag encountered by the wiper blades moving over the windshield exerts a braking force on the motor which varies with the condition of the windshield. When the wiper blades are operating over a wet windshield, such as during a heavy rainfall, they are well lubricated and the braking force is very small. When the wiper blades are operating over a wet-dry windshield, the braking force is significantly greater and decelerates the windshield wiping system faster during the decelerating period so as to bring the motor to a complete stop in a fewer number of degrees as compared to a wet windshield. By selecting a number of degrees θ between these two positions and automatically re-energizing the motor after θ degrees an effective degree-of-dryness control is achieved. When the windshield is very wet, the motor is re-energized to start another wiping cycle before the windshield wipers come to a complete stop during the decelerating period. This skips the dwell period and provides continuous operation. When the windshield is wet-dry or dry, the windshield wipers come to a complete stop during the decelerating period before the motor rotates through θ degrees. This starts a dwell period and suitable means are provided for energizing the motor at the end of the dwell period to start another cycle of operation.

In order to reduce the movement of the windshield wiper system during the decelerating period after the motor is de-energized near the end of a wiping cycle (that is, to reduce the angle θ), additional means may be provided for decelerating the windshield wiper system. This can take the form of spring elements positioned to cooperatively engage elements of the windshield wiper system to absorb some of the kinetic energy of the system during the decelerating period, or electrical or mechanical

braking means associated with the motor or other elements of the system. In the preferred embodiment, the motor is electrically braked by connecting a braking resistor thereacross to dynamically brake the motor during the decelerating period. The value of the resistor is carefully selected so as to cooperate with the drag encountered by the windshield wipers moving across the windshield to bring the system to a stop in a small number of degrees aftetr the motor is de-energized, but still at different angular positions depending on the condition of the windshield. This in effect reduces the aforementioned angle θ.

In accordance with another important feature, a transistor is employed in the control circuit for controlling the operation of the windshield wiper system. The transistor is shut OFF when the motor is de-energized near the end of each wiping cycle and automatically turned back ON by an RC time constant circuit to re-energize the motor after a predetermined dwell period if the system stops for a dwell period in response to the condition of the windshield. If the condition of the windshield dictates that the dwell period be skipped by re-energizing the motor before the system comes to a complete stop as described above, the transistor is automatically turned back ON after θ degrees of rotation to re-energize the motor and start the next cycle. The length of the dwell period is very conveniently controlled by a variable resistor in the RC time constant circuit.

The transistor control circuit just described also is very advantageous for producing intermittent operation without the automatically continuous feature. To assure a dwell period at the end of each cycle, regardless of the condition of the windshield, the value of the braking resistance is reduced significantly and this positively brakes the motor to a stop during the decelerating period at the end of each cycle, regardless of the condition of the windshield. The transistor control circuit is utilized as before to re-energize the motor and start the next cycle of operation after a predetermined dwell period.

SUMMARY OF THE INVENTION

In accordance with the present invention, a transistor control circuit is provided for energizing the wiper motor unit intermittently as described with a capactive timing included in the circuits for controlling the length of the dwell periods. The capacitive timing means includes a capacitor and a resistance. The capacitor is charged between dwell periods by applying the battery potential thereacross. During the dwell period the charged capacitor and resistance are connected in an RC circuit wherein the capacitor discharges through the resistance. When the capacitor discharges sufficiently it changes the condition of the transistor control circuit to end the dwell period and start the next wiping cycle.

An important advantage of the invention is the jumping of the potential on one side of the charged capacitor by a switch responsive to the position of wiper blades. This applies an initial potential drop across the resistance during the dwell periods which is greater than the battery potential. This enables the circuitry to utilize the steep portion of the discharge curve of the capacitor for controlling the length of the dwell periods.

Although the preferred embodiment of the invention is described for controlling a windshield cleaning system, the invention in its broader sense can be used for controlling successive time intervals of many other types of instrumentalities.

It is another object of the invention to provide a windshield wiper control system employing a transistor for selectively operating the windshield wipers intermittently or continuously in a manner to enable the dwell period of the intermittent operation and the speed of the continuous operation to be controlled by the transistor.

The features of novelty of the present invention will be specifically pointed out or will otherwise become apparent when referring, for a better understanding of the

invention, to the following description taken in conjunction with the accompanying drawings, wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a fragmentary view, partly in section and partly in elevation, of an automotive vehicle equipped with the windshield wiper system of this invention;

FIG. 2 is a schematic circuit diagram of one embodiment of a control system for providing intermittent windshield wiper operation in accordance with the invention;

FIG. 3 is a schematic circuit diagram of a second embodiment of a control system for producing intermittent windshield wiper operation in accordance with the invention;

FIG. 4 is a schematic circuit diagram of a third embodiment of a control system for producing intermittent windshield wiper operation in accordance with the invention;

FIG. 5 is a schematic circuit diagram of a fourth embodiment of a control system for producing intermittent windshield wiper operation in accordance with the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, a windshield wiper system is shown comprising a pair of wiper blades **10** and **12** carried by arms **14** and **16** which oscillate the wiper blades across the outer surface of a windshield **18** having a lower reveal molding **20**. The wiper arms **14** and **16** comprise conventional spring hinge connected inner and outer sections. The inner sections are drivingly connected to spaced pivot shafts **22** and **24** respectively, mounted beneath the lower reveal molding **20** and journalled in brackets **26** and **28**, respectively. The wiper blades **10** and **12** are driven by a suitable motor, such as a hydraulic, pneumatic or electric motor, which in this particular embodiment is an electric motor **30** attached to the fire wall **32** of the vehicle. The motor **30** has a rotating output shaft **34** which projects upwardly through the lower wall **36** of the plenum chamber **38** and has a radially extending crank arm **40** attached thereto which, in turn, has the inner ends of connecting links **42** and **44** rotatably connected thereto. The outer end of the link **42** is pivotally connected by a pin **46** to a crank arm **48** attached to the pivot shaft **22**. The outer end of the connecting link **44** is pivotally connected to one end of a bell crank **50** which is pivotally mounted on the bracket **28** by a pin **52** intermediate the ends thereof. The other end of the bell crank **50** is pivotally connected to a link **54** which is pivotally connected to a crank arm **46** attached to the pivot shaft **24**.

If desired, the wiper blades **10** and **12** can be oscillated throughout their running strokes and automatically moved to a depressed park position wherein they firmly engage the lower reveal molding **20** as illustrated in FIG. 1 when the wiper motor **30** is inactivated by the operator of the vehicle. Pat. No. 2,985,024 illustrates one arrangement for automatically moving the wipers to the aforementioned depressed park position when the wipers are turned off by the operator of the vehicle. In addition, the wiper motor **30** may be used to drive a washer pump mechanism **58** for supplying cleaning fluid from a reservoir **60** to a pair of nozzles **62** and **64** mounted adjacent to the pivot shafts **22** and **24**, respectively.

Referring to FIG. 2, a control circuit **70** embodying features of the invention is illustrated for controlling the operation of the wiper motor **30** throughout the running cycle of the wiper blades **10** and **12**. The motor is a single speed DC motor with a field provided by a permanent magnet. One side of the motor **30** is connected to a negative voltage —B (the negative terminal of the battery) and the other side is connected to ground through the collector and emitter of a transistor **72**. The base of the transistor is connected to one side of a capacitor **74** with

the other side of the capacitor connected to a movable contact **76** which normally engages a fixed contact **78** connected to the negative voltage —B. One side of a variable resistor **80** is connected between the capacitor **74** and the base of the transistor **72** and the other side is connected to the negative voltage —B. A stationary contact **82** connected to ground is positioned to be contacted by the movable contact **76**.

The movable contact **76** is tripped near the end of a wiping cycle and remains in contact with the contact **82** for θ degrees of rotation of the motor output shaft **34** after which it is released and re-engages the contact **78**. One way of accomplishing this is to provide a cam follower **84** which is actuated by a cam **86** which rotates with the output shaft **34** of the motor. In this embodiment, one complete revolution of the shaft **34** produces one complete wiping cycle of the wiper blades **10** and **12**. That is, one complete revolution produces a forward stroke of the wiper blades and a return stroke back to the starting position of the wiping cycle. Of course, by simple gearing changes one revolution of the shaft **34** could be made to produce two or more strokes per cycle, if desired. The cam **86** has an arcuate length corresponding to the aforementioned angle θ and is designed to actuate the cam follower **84** to trip the movable contact **76** to break the circuit with the contact **78** and make the circuit with the contact **82** at a predetermined point near the end of the return stroke, that is, near the end of one complete wiping cycle, and to hold the movable contact **76** in this position while the shaft **34** rotates through a small angle of θ degrees. After the shaft **34** moves through the angle θ, the cam follower **84** drops off the cam **86** and the movable contact **76** returns to the position illustrated in FIG. 2.

The control circuit **70** operates in the following manner. The transistor **72** is ON when its base is negative and the collector is near ground. Consequently, full power from the negative voltage —B is applied to the motor **30** when the movable contact **76** engages the contact **78** as illustrated and the motor runs to operate the wiper blades through a wiping cycle. When the cam follower **84** shifts the movable contact **76** against the stationary contact **82** near the end of the return stroke of the wiping cycle, as previously described, the side of the capacitor connected to the movable contact **76** changes by an amount of voltage —B. Since the voltage across the capacitor cannot change instantaneously, the other side of the capacitor also changes by the voltage B so as to be jumped to a +B voltage, the magnitude of which depends on the amount the capacitor **74** is charged during a wiping cycle. This makes the transistor base positive which turns the transistor OFF and the motor stops. The capacitor and variable resistor combination discharges, and toward the —B potential connected to the variable resistance **80**. After some discharge time, the transistor base again becomes negative when the potential on the side of the capacitor **74** connected to the transistor base changes from positive to negative as it discharges from +B to —B to turn the transistor ON and energize the motor to start the next wiping cycle. If the capacitor **74** is fully charged to the battery potential B during a wiping cycle, it is apparent from the foregoing that the potential at the juncture of the variable resistance **80** and the capacitor **74** is +B at the start of a dwell period so as to impose a 2B potential (twice the battery voltage) across the variable resistance **80**. Since the transistor turns on shortly after the base becomes negative, it turns on shortly after the capacitor discharges a little more than half way, thus the steep portion of the capacitor discharge curve is utilized for controlling the length of time of the dwell periods. This enables the length of time of the dwell periods to be varied more effectively.

The momentum of the motor and wiper mechanism keeps the motor rotating through a small angle after the transistor **72** is turned OFF to de-energize the motor during the decelerating period as previously described, and the drag of the wiper blades **10** and **12** moving across the windshield applies a braking force to the motor during this decelerating period which is related to the degree-of-dryness of the windshield. The drier the windshield, the greater the rate of deceleration and the sooner the motor stops. The drag encountered by the wiper blades moving over the windshield also determines the velocity of the wiper blades at the time they enter into the decelerating period near the end of the return stroke of the wiping cycle. This, of course, has a direct bearing on the momentum of the motor and wiper mechanism.

If the motor **30** stops in less that θ degrees, the cam follower **84** remains on the cam **86** and the movable contact **76** remains in contact with the stationary contact **82**. Therefore, the motor **30** is de-energized as long as the transistor **72** is OFF. As the capacitor **74** discharges through the variable resistor **80**, the transistor base again becomes negative after a period of time, as previously described, and the transistor turns ON to start the next cycle. The time the transistor is OFF is the dwell period of the intermittent windshield wiper operation and the length of the dwell period can be controlled by the variable resistor **80**. For example, the dwell period can be set anywhere from one to twenty seconds. When the transistor turns ON, to start another wiping cycle, the cam follower **84** drops off of the cam **86** to enable the movable contact **76** to return to the stationary contact **78**, as illustrated in FIG. 2, to prepare the circuit for the next dwell period.

In the event a heavier rainfall is encountered, or water is sprayed on the windshield from a vehicle being passed, the dwell period is automatically skipped. The movable contact **76** is again tripped by the cam follower **84** near the end of the return stroke of the wiper blades **10** and **12** to turn the transistor OFF. However, since the wiper blades are operating over a wet windshield, the cam follower **84** drops off of the cam **86** before the motor is decelerated to a complete stop. As soon as this occurs, the movable contact **76** is tripped back to the position illustrated in FIG. 2 to turn the transistor **72** ON and energize the motor to start the next wiping cycle immediately and skip the dwell period. As long as the windshield remains wet, the dwell period at the end of each cycle will be skipped and the wiper blades will operate continuously. However, as soon as the rainfall decreases, or the vehicle is passed so that water from the road is no longer sprayed onto the windshield, the wiper blades will automatically stop for a predetermined dwell period at the end of each wiping cycle.

Referring to FIG. 3, a control circuit **71** is illustrated which reduces the aforementioned angle θ, or stated otherwise makes the motor **30** stop in a fewer number of degrees after it is de-energized at the end of a cycle. In this embodiment, the inertia of the load on the motor which tends to keep it moving after the motor has been de-energized is used to drive the motor as a generator during the decelerating period. To accomplish this, another switch section **88** is added as illustrated in FIG. 2 which includes a stationary contact **90** connected to the negative voltage —B and a movable contact **92** connected to one end of a brake resistor **94**, the other end of the brake resistor being connected to the same side of the motor **30** as the transistor collector.

When the movable contacts **76** and **92** are tripped to engage the contacts **82** and **90**, respectively, to start the decelerating period, the brake resistor **94** is connected across the motor armature which is the output when the motor is operating as a generator. Consequently, the kinetic energy of the system which drives the generator is converted to electrical energy which is dissipated in the brake resistor **94**. This dynamically brakes the motor during the deceleration period to bring the motor to a complete stop in a fewer number of degrees after it has been de-energized. As before, the length of the dwell period is determined by the setting of the variable resistor **80**.

By using a brake resistor **94** with a very low value, the motor can be made to stop almost immediately so that a dwell period will occur at the end of each wiping cycle regardless of the condition of the windshield. However, for a given windshield wiper system for a given vehicle, the value of the brake resistor **94** can be selected to cooperate with the drag encountered by the wiper blades moving over the windshield to produce intermittent operation when the windshield is in a wet-dry condition and to skip the dwell period to produce continuous operation when the windshield is in a wet condition.

To review the over all operation of the control circuit **71**, the movable contacts **776** and **92** are tripped over a range of θ degrees which is determined by the arcuate length of the cam **86** which, in turn, is less than the arcuate length of the cam in FIG. 2 because of the electrical braking referred to above. Mechanical energy is dissipated in the system as the wiper blades move across the windshield surface. When the windshield is wet, viscous friction dominates and when the windshield is dry, coulomb friction dominates. At intermediate degrees-of-dryness, the effective friction coefficient varies which, in turn, regulates the amount of kinetic energy consumed mechanically. The inertia of the system, the decelerating period as determined by the angle θ, the geometry of the wiper system, the setting of the voltage regulator of the vehicle, and other relevant factors are all taken into account in establishing the value of the brake resistor **94**. By adjusting the system so that the motor **30** does not stop in θ degrees under wet windshield conditions, but does stop in θ degrees under wet-dry windshield conditions, the desired continuous or intermittent operation is achieved automatically. Thus, with a wet windshield, when the movable contacts **76** and **92** are tripped to initiate the decelerating, the kinetic energy is not dissipated in the angular region defined by the cam **86** and full power is again applied to continue into another wiping cycle. With an intermediate degree-of-dryness of the windshield (wet-dry), the kinetic energy is dissipated within the angular region θ and the motor comes to a complete stop. When the base becomes negative again to turn the transistor back ON, current goes from ground through the emitter and base of the transistor to charge the capacitor **74** to provide power for the next cycle through the emitter and collector of the transistor. The capacitor can charge very quickly and, as is well known, the collector current flows only when the base current flows. At full speed of the motor it takes about one second to complete a wiping cycle. Thus, if the capacitor charges too quickly, the wiper blades may not cycle under full power. When the motor loses power, the wiper blades may hesitate until the base times out longer and becomes more negative, and this hesitation would be distracting to the driver. In order to prevent hesitation a resistor **96** is placed in series with the capacitor **74** to limit the rate of charge of the capacitor so that it takes about one second for the capacitor to charge. This assures that a full wiping cycle occurs under full power.

In the embodiment of FIG. 3, the brake resistor **94** is used to dynamically brake the motor **30** electrically during the decelerating period. As stated previously, a mechanical brake could be employed to assist the drag of the wiper blades on the windshield in decelerating the motor. However, in its broader aspects, the invention also contemplates using other techniques for decelerating the wiper system in a manner to produce or skip the dwell period at the end of each wiping cycle. For example, a spring or other type of biasing force could be positioned to engage an element of the wiper system at a predetermined point in each wiping cycle to apply a controlled mechanical decelerating force thereto during the decelerating period to assist the drag of the wiper blades on the windshield in bringing the motor to a complete stop when the windshield is in a wet-dry condition to start a dwell period, and to skip the dwell period when the windshield is in a wet condition. It also will be appreciated that the decelerating period can occur at some other predetermined portion of each wiping cycle, such as nearer the beginning of the return stroke of the cycle, and a measurement made of the drag encountered by the wipers to determine whether the wipers are to be stopped for a dwell period at the end of the cycle, or whether the dwell period is to be skipped to produce continuous operation automatically.

In accordance with another feature of the invention, the control circuit **71** of FIG. 3 can be easily adapted to positively stop the wiper blades at the end of a wiping cycle under the control of the driver by simply adding a normally open switch **98** in position to short out part or all of the brake resistor **94** and a normally closed switch **100** between the variable resistor **80** and negative voltage —B. The dashboard of the vehicle would be provided with a suitable control knob having an intermittent position and an off position. When the driver turns the control knob to the intermittent position, the contacts of the control device **71** are positioned as illustrated in FIG. 3, and the wiper system operates intermittently or continuously depending on the condition of the windshield. When the driver turns the control knob to the off position, switch **98** closes to reduce the brake resistance and switch **100** opens to disconnect the variable resistor **80** from the negative voltage —B. The wipers will continue to operate until the end of the wiping cycle in progress at which time the cam **86** will trip the movable contacts **76** and **92** into engagement with the stationary contacts **82** and **90**, respectively. This turns the transistor **72** OFF and since the value of the braking resistance is significantly decreased, the motor **30** positively will come to a complete stop before the cam **84** can ride off of the cam **86** regardless of the degree-of-dryness of the windshield. The transistor **72** cannot turn back ON because the switch **100** remains open in the off position and, therefore, the wiper system is completely deactivated with the blades stopped at the end of the return stroke, rather than in a depressed parked position as in the aforementioned Pat. 2,985,024. In some systems presently being used on automotive vehicle, the motor armature is shorted to brake the motor when the wipers are turned off by the driver. However, in the control circuits **70** and **71** of FIGS. 2 and 3, it is very important that some brake resistance greater than zero be used for braking the motor during intermittent operation. When the transistor **72** turns ON at the end of each dwell period to start a new cycle, the load consists of the armature and braking resistor **94** in parallel. At standstill, the motor impedance is two ohms and the brake resistor **94** is two ohms, and the initial surge current which the transistor **72** must supply is approximately twelve amps. As the motor rotates, the impedance of the armature increases and the brake resistor **94** is removed after a few degrees of rotation when the cam follower **84** rides off of the cam **86**. It is apparent that if the brake resistor **94** were zero (the equivalent of shorting the motor armature) the transistor surge current would have to be infinite.

Referring to FIG. 4, a control circuit **120** is shown which illustrates a more sophisticated embodiment of the invention. In this embodiment, three transistors **122**, **124** and **126**, are used in place of the single transistor **72**. It will be noted that all three collectors are tied together as one transistor and that all three emitters are connected to ground with resistors **127** and **128** provided for temperature compensation. By using the three transistors, in place of the one transistor **72** used in the control circuits **70** and **71**, the cost can be significantly reduced because each of the three transistors can be a cheaper grade transistor. With the present state of the art, the three transistors have a total cost which is less than the cost of the single transistor **72** which must be of a much higher quality. Of course, two transistors could be used or additional transistors added to the three transistors if additional economies could be realized.

The collectors of the transistors **122–126** are connected to one side of the motor **30** and the other side of the motor is connected to a negative voltage —B as previously described. The movable contacts **76** and **92** are provided as before along with stationary contacts **78**, **82** and **90**, contacts **78** and **90** being connected to the negative voltage —B and contact **82** being connected to ground. As in the embodiments of FIGS. 2 and 3 the movable contacts **76** and **92** are mechanically tripped to engage the stationary contacts **82** and **90** for θ degrees of rotation of the motor shaft **34** to define the decelerating period near the end of each wiping cycle.

In this embodiment the control knob (not shown) which is mounted on the dashboard in a position to be operated manually by the driver has three sets or sections of stationary contacts, I, C and O adapted to be selectively engaged by movable contacts **130**, **132** and **134**. With this arrangement, the driver can adjust the control knob manually to provide intermittent operation, continuous operation, or to turn the wipers off. The movable contacts **130–134** engage stationary contacts I to provide intermittent operation, engage the stationary contacts C to provide continuous operation, and engage the stationary contacts O to turn off or deactivate the wipers as will be described.

The movable contact **76** is connected directly to the movable contact **130** and one side of the capacitor **74** is connected to the stationary contact I associated with the movable contact **130**. The other side of the capacitor **74** is connected to the resistor **96** and the other end of the resistor **96** is connected directly to the base of the transistor **122**. As will be recalled, the function of the resistor **96** in the previous embodiment is to prevent the capacitor **74** charging too quickly so that full power will be supplied to the motor during a complete wiping cycle. The resistor **96** serves the same function in this embodiment. One end of the variable resistor **80** is connected to a resistor **140** which in turn is connected to the juncture between the resistor **96** and the base of the transistor **122**. The other end of the variable resistor **80** is connected to the movable contact **132** so that it will be connected to the negative voltage —B when the movable contact **132** engages the stationary contact I as illustrated. The stationary contact C associated with the movable contact **132** is connected directly to the side of the motor to which the transistor collectors are connected. The juncture between the variable resistor **80** and the resistor **140** is connected directly to the stationary contact O associated with the movable contact **130**.

The movable contact **134** is connected to one end of the brake resistor **142** and the other end of the brake resistor is connected directly to the same side of the motor **30** to which the collectors of the transistors are connected. A second braking resistor **144** is connected between the stationary contact I associated with the movable contact **134** and the movable contact **92**. If desired, additional braking resistors **146** and **148** may be connected in parallel with the brake resistors **142** and **144**, respectively, to reduce the value of the total resistance. During intermittent operation the brake resistors **142** and **144** perform the same function as the brake resistor **94** in the previous embodiments, as will be described.

When the driver turns the wipers on intermittent operation by means of the control knob on the dashboard of the vehicle, each of the movable contacts **130–134** engage the stationary contacts I as illustrated in FIG. 4. Assuming the movable contact **76** engages the stationary contact **78**, the base of the transistor **122** is connected to the negative voltage —B through the movable contact **130**, the capacitor **74** and the resistor **96** so that the transistors are ON. Therefore, the motor **30** is energized because the circuit from the negative voltage —B through the motor to ground is completed through the collectors and emitters of the transistors **122–126** since they are ON. While the motor is energized to provide the power for the wiping

cycle in progress, the movable contact **92** is in the position illustrated out of engagement with the stationary contact **90** so that the brake resistors **142** and **144** are not connected in the circuit. As the wiper blades near the end of the return stroke of the wiping cycle, the movable contacts **76** and **92** are mechanically tripped, as in the previous embodiments, to engage the stationary contacts **82** and **90**, respectively. This turns the transistors OFF and de-energizes the motor **30** as before, and connects the brake resistors **142** and **144** in series across the motor to provide the electrical brake provided by the resistor **94** in the previous embodiments.

Depending upon the degree-of-dryness of the windshield the motor will either continue to rotate through the angle θ and thereafter release the movable contacts **76** and **92** to re-energize the motor to start another wiping cycle (continuous operation), or the motor will come to a stop before the movable contacts **76** and **92** are released so that the wiper blades will dwell for a period determined by the length of time the transistors **122–126** are OFF. As in the previous embodiments the transistors will remain OFF until the capacitor **74** discharges sufficiently to make the base of the transistor **122** negative to turn the transistor **122** and the other two transistors back ON. The variable resistor **80** can be adjusted to control the length of the dwell period. When the transistors turn back ON, the motor **30** is energized to start another wiping cycle and the movable contacts **76** and **92** trip back to the position illustrated in FIG. 4 as soon as the motor rotates through a few degrees.

When the driver turns the dashboard control knob to the continuous position, the movable contacts **130–134** each engage the stationary contacts C associated therewith. This removes the brake resistors **142** and **144** from the circuit and also removes the resistor **96** and capacitor **74** from the circuit. However, the base of the transistor **122** is connected to the same side of the motor **30** as the collectors of each of the transistors. This circuit can be followed through the resistor **140**, the variable resistor **80**, the movable contact **132** and stationary contact C. In this position the transistors **122–126** are always ON due to the current flow from the motor through the base-emitter circuits of each of the transistors to ground. Therefore the motor is continuously energized because it is connected directly to ground through the collector-emitter circuits of each of the transistors. An important advantage of this circuit is that the variable resistor **80** which is used to control the length of the dwell period during intermittent operation also can be used to vary the speed of the motor **30** in the continuous operation position. By adjusting the value of the variable resistor **80** the current flow through the base-emitter circuits of each of the transistors can be adjusted to control the magnitude of the primary current flow to the motor through the emitter-collector circuits of each of the transistors.

For any given setting of the variable resistor **80**, the transistors automatically increase current flow to the motor **30** when the motor slows down in response to increase load to provide improved speed regulation. When the motor slows down its back EMF decreases to reduce the potential drop across the motor. This causes the potential at the contact C associated with the movable contact arm **132** and the potential at the base of the transistor **122** to move toward —B. This increases the base current flow through the transistors which, in turn, produces an increased emitter-collector current flow to the motor to increase the torque of the motor and thus resist slowing down of the motor.

As previously described, in some more sophisticated windshield wiper control systems presently in use, the windshield wipers are automatically parked in a depressed park position adjacent the windshield wiper molding when they are turned off, instead of being parked one half to one inch above the reveal molding as they are in systems which merely stop the wipers at the end of a wiper stroke.

The circuit of FIG. 5 shows the present invention applied to a wiper control system for Chrysler automobiles which automatically parks the wipers in a depressed park position. The circuit shown in FIG. 5 is similar to that shown in FIG. 4 except that the circuit makes use of a Chrysler wiper motor having a series field winding **170** and a shunt field winding **172** instead of a permanent magnet field. The armature of the wiper motor in FIG. 5 is designed by the reference number **165**. The transistors **122, 124** and **126** are connected together and to the resistors **127** and **128** in the same manner that they are connected in FIG. 4. Also, the movable contact **132** is connected to the base of the transistor **122** through the series circuit of the resistors **80** and **140** in the same manner as in FIG. 4. Similarly, the stationary contact I associated with the movable contact **130** is connected to the base of the transistor **122** through the capacitor **74** and the resistor **96** in the same manner as in FIG. 4. The movable contacts **130** and **76** and the stationary contacts **78** and **82** are also connected in the same manner as in FIG. 4 and the washer motor **160** and the washer switch **162** are connected to the circuit in the same manner as in FIG. 4. The stationary contact C associated with movable contact **130** is open circuited as in the circuit of FIG. 4. However, the stationary contact O associated with the movable contact **130** is open circuited instead of being connected to the junction between the resistors **80** and **140**. The stationary contact **90** is connected to —B potential and the movable contact **92** is connected to the stationary contact I associated with the movable contact **134** through a single brake resistor **174**. The stationary contact O associated with the movable contact **134** is connected directly to ground. The stationary contact C associated with the movable contact **134** is open circuited. The movable contact **134** is connected to the junction between the armature **165** and the series field winding **170** through a normally closed switch **176**. The stationary contact O associated with the movable contact **132** is open circuited, and the stationary contact I is connected to —B potential. The stationary contact C associated with the movable contact **132** is connected to the collectors of the transistors **122–126** as in the circuit of FIG. 4. However, the stationary contact C associated with the movable contact **132** and the collectors of the transistors **122** and **124** and **126** are connected to the wiper motor in a different manner from the circuit of FIG. 4, as will be described.

To control the operation of the wiper motor, three additional movable contacts, **178, 180** and **182** are provided to be operated by the dashboard-mounted control knob, together with the movable contacts **130, 132** and **134**. Accordingly, the movable contacts **178, 180** and **182** each have associated therewith three stationary contacts, I, C and O. The commonly connected collectors of the transistors **122, 124** and **126** as well as the stationary contact C associated with the movable contact **132** are all connected to the stationary contact I associated with the movable contact **178** and to the stationary contact C associated with the movable contact **180**. The series field winding **170** connects the movable contact **178** to one side of the armature **165**, the other side of which is connected to —B potential. The stationary contact C associated with the movable contact **178** is connected to ground, and the stationary contact O associated with the movable contact **178** is connected to the stationary contact O associated with the movable contact **182**. The shunt field **172** connects the movable contacts **180** and **182** together. The stationary contact I associated with the movable contact **180** is connected to ground through a resistor **184** and the stationary contact O associated with the movable contact **180** is connected to —B potential. The stationary contacts I and C associated with the movable contact **182** are also connected to —B potential.

The speed of operation of wiper motor armature **165** is controlled by the amount of current flowing through the shunt field winding **172**. The motor speed is inversely proportional to this field current and, therefore, the greater the current flow through the field winding **172**, the slower the motor will operate and vice versa. When the dashboard control knob is turned to the continuous position by the driver, it will be noted that an armature **165** and the series field winding **170** will be connected between —B potential and ground and the shunt field winding **172** will be connected between —B and the collectors of the transistors **122, 124** and **126**, the collectors also being connected to the base of the transistor **122** through the variable resistor **80** and the resistor **140**. Thus, the current through the shunt field winding **172** during the continuous operation will be controlled by the transistors **122, 124** and **126** in accordance with the value of the resistor **80** in the same manner as the current through the wiper motor **30** in the circuit of FIG. 4 is controlled during continuous operation. Thus, the speed of the wiper motor in the circuit of FIG. 5 will be controlled during continuous operation by means of variable resistor **80**. It should be noted however, that in the circuit of FIG. 5 the speed will be changed in the opposite direction from that of the circuit of FIG. 4 in response to changes in the value of the resistor **80** in a given direction.

When the dashboard control knob is moved to the off position, a series circuit will be formed comprising the series field winding **170** and the shunt field winding **172** connected between the —B potential applied at the stationary contact O associated with the movable contact **180** and ground applied at the stationary contact O associated with the movable contact **134**. As as a result current will flow through the field windings **172** and **170** in the reverse direction. Also, the armature **165** will be connected between —B potential and ground applied at the stationary contact O associated with the movable contact **134**. Because current flows through field windings **170** and **172** in the reverse direction, the motor will drive the wiper blades in the reverse direction. The Chrysler system is arranged so that when the wiper motor is driven in the reverse direction, the wipers move to the depressed park position. Upon reaching the depressed park position the normally closed switch **176** is opened by a cam (not shown) which functions to open the switch **176** only when the motor **162** is moving in the reverse direction. When the switch **176** opens, power is disconnected from the field windings **170, 172** and from the armature **165** so that the motor stops and the wipers are stopped in the depressed park position. Since the mechanism for moving the wipers to depressed park and camming the switch **176** open is part of a conventional Chrysler wiping system, it has not been illustrated.

When the dashboard control knob is turned to the intermittent position, the shunt field winding **172** will be connected in series with resistor **184** between —B potential and ground so that current flows through the shunt field winding **172** in the forward direction. The armature **165** will be connected in series with the series field winding **170** between —B potential and the collectors of the transistors **122, 124** and **126**. The junction between the armature **165** and the series field winding **170** will be connected through the resistor **174** to the movable contact **92**. The circuit will then function in a manner similar to that in FIG. 4. When the transistors **122, 124** and **126** are conducting, as they will be when the movable contacts **76** and **92** are in the position shown in FIG. 5, current will flow from —B potential through the armature **165**, the field winding **170** and the transistors **122, 124** and **126** to ground and the wiper motor will drive the wipers at a speed determined by the current flowing in the field winding **172** which, in turn, is determined by the resistor **184**.

When the wipers approach the end of the return stroke, the movable contact **92** engages the contact **90** and the contact **76** disengages from the contact **78** and engages the contact **82**. As a result, a positive potential is applied at

the base of the transistor **122**, cutting the transistors **122**, **124** and **126** OFF. At the same time, the resistor **174** is connected across the armature **165**, providing electrodynamic braking of the wiper motor. If the electrodynamic braking, together with the mechanical braking of the drag of the wipers on the windshield, is sufficient to stop the motor in less than θ degrees, a dwell period is produced until the capacitor **74** can become sufficiently charged through the resistors **80**, **140** and **96**, to turn the transistors **122**, **124** and **126** ON again to re-energize the wiper motor and start another wiping cycle. If the mechanical braking, together with electrodynamic braking, is insufficient to stop the motor in θ degrees (the decelerating period) the contacts **76** and **92** return to the position illustrated and automatically re-energize the motor in the same manner as in the circuit of FIG. 4 to skip the dwell period. The duration of the dwell period, as in the circuit of FIG. 4, is determined by the value of the resistor **80**.

The point at which the system automatically switches between continuous operation and intermittent operation can be controlled by adjusting the value of the brake resistor **174** or the value of the resistor **184**. The value of the brake resistor determines the amount of electrodynamic braking as already described, and the value of the resistor **184** controls the speed of the wiper motion. If the value of the resistor **184** is decreased to increase the wiper motor speed, more braking action will be required to stop the wipers in the decelerating period of the wiping cycle. Thus a decrease in the value of the resistor **184** will cause automatic switch between continuous and intermittent to take place when the window is drier. Similarly an increase in the value of the resistor **184** will cause the automatic switching to take place when the windshield is wetter. Preferably, however, the value of the resistor **184** is selected to produce the desired wiper speed and the value of the brake resistor **174** is selected to determine the degree-of-dryness of the windshield at which the automatic switching takes place. If desired the brake resistor **174**, as well as the brake resistors of the other embodiments, can be made variable to enable the automatic switching point to be adjusted to meet the preference of the owner of the vehicle. This also would provide a convenient means for making any future adjustment which might be necessary after a prolonged period of operation.

While it will be apparent that the embodiments of the invention disclosed herein are well calculated to fulfill the objects of the invention, it will be appreciated that the invention is susceptible to variation, modification and change without departing from the proper scope or fair meaning of the appended claims.

What is claimed is:

1. A timing circuit for determining repeated spaced time intervals comprising a capacitance, a resistance, and circuit means repeatedly charging and discharging said capacitance, charging said capacitance between said time intervals to provide a voltage across said capacitance at the start of each of said intervals and discharging said capacitance during said intervals by connecting said resistance and said capacitance in an RC circuit with said resistance connected to one side of said capacitance, said circuit means including switch means automatically jumping the potential applied to the other side of said capacitance a time period after the end of each interval to start the following interval, said jumping being in a direction to increase the voltage across said resistance, said circuit means terminating said intervals when the voltage across said resistance drops to a predetermined level, said circuit means including an electronic valve having a first conductive condition and a second conductive condition, said circuit means connecting said electronic valve to said resistance during said intervals in a manner to switch said electronic valve from said first condition to said second condition to terminate each of said intervals in response to the voltage across said resistance dropping to said predetermined level, said circuit means including a DC source, the switching of said electronic valve from said first condition to said second condition being in response to the voltage between a pair of electrodes of said electronic valve having a predetermined polarity and reaching the switching level for said electronic valve, said circuit means during said intervals connecting said resistance between said one side of said capacitance and one side of said DC source, connecting one of said electrodes to the other side of said DC source, and connecting the other one of said electrodes to said resistance, whereby the voltage between said electrodes will reach said switching level with said predetermined polarity to cause said electronic valve to switch from said first condition to said second condition when the voltage across said resistance drops to said predetermined level.

2. A control device for activating motor driven windshield wiper drive means for driving wiper blades across a windshield in repeating wiping cycles comprising a timing circuit as recited in claim **1** and activating means including said timing circuit for activating said drive means intermittently to provide dwell periods between succesive wiping cycles, said activating means terminating each dwell period to initiate the wiping cycle when said circuit means terminates a time interval determined by said timing circuit.

3. A control device for activating motor driven windshield wiper drive means for driving wiper blades across a windshield in repeating wiping cycles comprising: (1) a timing circuit for determining repeated spaced time intervals comprising a capacitance, a resistance, and circuit means to charge said capacitance between said time intervals to provide a voltage across said capacitance at the start of each of said intervals and to connect said resistance to one side of said capacitance in an RC circuit during said intervals, said circuit jumping the potential applied to the other side of said capacitance at the start of each of said intervals in a direction to increase the voltage across said resistance, said circuit means terminating said intervals when the voltage across said resistance drops to a predetermined level, and (2) activating means including said timing circuit for activating said drive means intermittently to provide dwell periods between successive wiping cycles, said activating means terminating each dwell period to initiate a wiping cycle when the circuit means terminates a time interval determined by said timing circuit.

4. A control device as recited in claim **3** wherein said circuit means includes a DC source and wherein the voltage across said resistance is increased to a value greater than the voltage provided by said DC source when the potential on the other side of said capacitor is jumped at the start of each of said intervals.

5. A control device as recited in claim **3** wherein said circuit means includes an electronic valve having a first conductive condition and a second conductive condition, said circuit means connecting said electronic valve to said resistance during said intervals in a manner to switch said electronic valve from said first condition to said second condition to terminate each of said intervals in response to the voltage across said resistance dropping to said predetermined level.

6. A control device as recited in claim **5** wherein said circuit means includes a DC source, wherein the switching of said electronic valve from said first condition to said second condition is in response to the voltage between a pair of electrodes of said electronic valve having a predetermined polarity and reaching a predetermined level, and wherein during said intervals said circuit means connects said resistance between said one side of said capacitance and one side of said DC source, connects one of said electrodes to the other side of said DC source, and connects the other one of said electrodes to said resistance, whereby the voltage between said electrodes

will reach the predetermined level with said predetermined polarity to cause said electronic valve to switch from said first condition to said second condition when the voltage across said resistance drops to the predetermined level at which said circuit means terminates said intervals.

7. A windshield wiper control comprising an electric wiper motor unit for driving wiper means through repeating wiping cycles, and control means for automatically energizing and de-energizing said wiper motor unit to produce complete wiping cycles with a dwell period between successive wiping cycles, the time interval of said dwell periods being infinitely variable between zero and a pre-determined maximum time interval, said control means comprising electronic valve means connected in series with said wiper motor unit for controlling the energization of said wiper motor unit at the end of each of said time intervals to initate the next wiping cycle, capacitive timing means connected to said electronic valve means for controlling the length of time of each of said time intervals and turning said electronic valve means on at the end of each of said time intervals when the charge on the capacitor of said capacitive timing means reaches a predetermined level, switch means responsive to the position of said wiper motor unit for initiating each of said time intervals and conditioning said capactive timing means to turn on said electronic valve means at the end of each of said time intervals, and a manual control for varying from zero to said predetermined maximum time interval the time required for the charge on said capacitor to reach said predetermined level.

8. The windshield wiper control of claim 7 wherein said time intervals are determined by the length of time required for the charge on said capacitor to change from a base reference level to said predeterminded level, and wherein said switch means responsive to the position of said wiper motor unit returns said capacitor to said base reference level for the start of each of said time intervals.

9. The windshield wiper control of claim 7 wherein said switch means responsive to the position of said wiper motor unit changes the charge on said capacitor from said predetermined level to another predetermined level before the start of each of said time intervals.

10. The windshield wiper control of claim 9 wherein said switch means responsive to the position of said wiper motor unit is in a first position during each of said time intervals and switches to a second position after a wiping cycle has been initiated by said electronic valve means, said capacitor charge returning to said other predetermined level while said switch means is in said second position.

11. The windshield wiper control of claim 10 wherein the return of said capacitor charge to said other predetermined level is initiated by the switching of said switch means to said second position.

12. The windshield wiper control of claim 7 wherein said capacitive timing means includes a transistor having the base thereof connected to one side of said capacitor, said transistor being de-energized during each of said time intervals and being biased on by said capacitor at the end of each of said time intervals to energize said electronic valve means to initiate the next wiping cycle.

13. The windshield wiper control of claim 12 wherein said switch means responsive to the position of said wiper motor unit is connected in the base circuit of said transistor so as to carry base current rather than amplified motor current.

14. The windshield wiper control of claim 7 wherein said control means includes a transistor and said switch means responsive to the position of said wiper motor unit is connected in the base circuit of said transistor so as to carry base current rather than amplified motor current.

15. A windshield wiper control for a wiper moveable back and forth across the surface of a windshield, including an electric motor operable to oscillate the wiper and park the wiper in a predetermined position, an electric power source, an energizing circuit for said motor including a cyclically actuated parking switch operated by said motor, said parking switch normally being in a first position during movement of the wiper and a second position when the wiper is in said predetermined position, semiconductor switch means connected in series with said motor for controlling energization of said motor when said parking switch is in said second position, a variable resistor-capacitor timing means connected in circuit with said semi-conductor switch means, a manual control connected with said power source and variable timing means for varying the time constant of said timing means to effect a one cycle operation on said wiper motor with the time interval between successive cycles of wiper operation being infinitely variable between zero and a predetermined maximum time interval, said semi-conductor switch means being in an off condition when said parking switch is in said second position until the charge of the capacitor reaches a predetermined level to turn said semi-conductor switch means on and initiate the next wiping cycle, the time for said charge to reach said pre-determined level being infinitely variable by said manual control between zero and said predetermined maximum time interval.

16. A control device for controlling motor driven windshield wiper drive means for driving wiper blades across a windshield in repeating wiping cycles comprising circuit means for activating said drive means intermittently to produce complete wiping cycles with a dwell period between successive wiping cycles, said circuit means having first and second quasi-stable states and including a capacitor, and switch means having first and second positions responsive to the position of the wiper blades, said drive means being deactivated and said switch means being in said first position and said capacitor decreasing its charge when said circuit means is in said first quasi-stable state, said drive means being activated and said switch means being in said second position and said capacitor increasing its charge through said switch means when said circuit means is in said second quasi-stable state.

17. The control device of claim 16 wherein the transition from said first to said second quasi-stable state is time dependent and the transistion from said second to said first quasi-stable state is dependent upon the position of the blades.

18. The control device of claim 16 wherein said circuit means includes a solid state switch which is in a first condition when said circuit means is in said first quasi-stable state and in a second condition when said circuit means is in said second quasi-stable state, and wherein the charging current of the capacitor is conducted through said solid state switch when the latter is in said second condition.

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