May 28, 1963 V. E. ADRIG 3,091,680

ICE DETECTOR

Filed Oct. 28, 1960 3 Sheets-Sheet 1

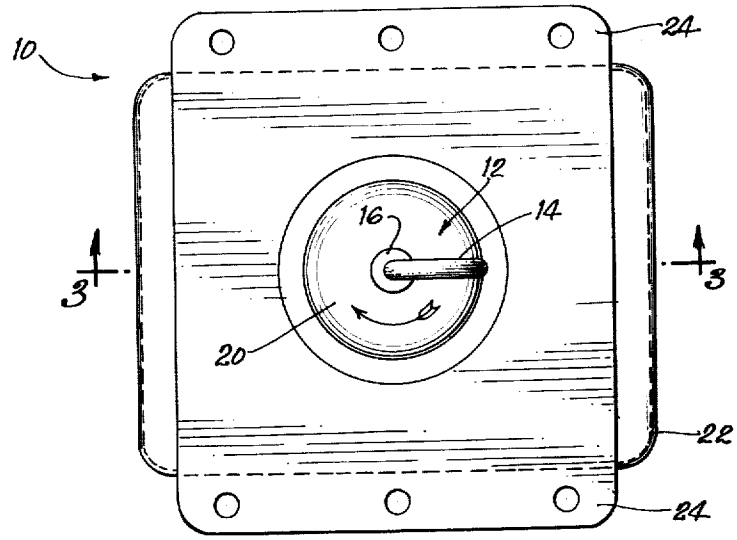


FIG. 1

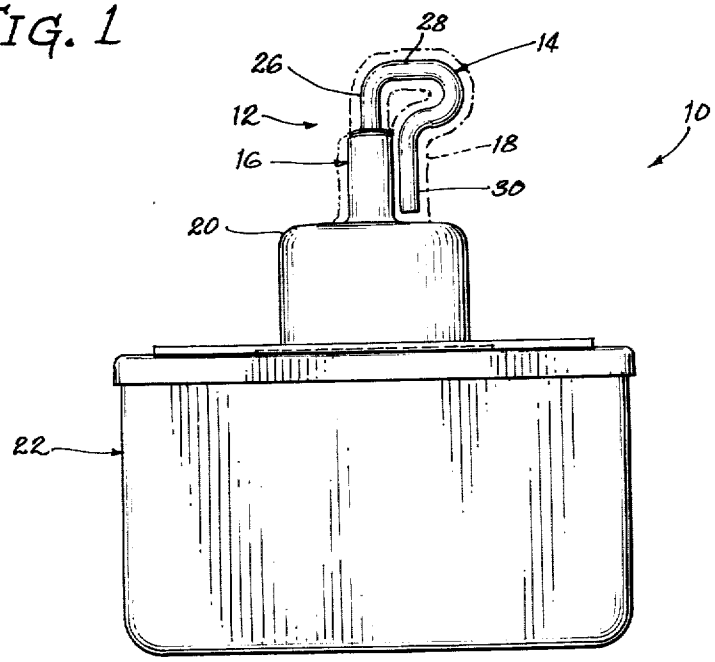


FIG. 2

INVENTOR.
Vernon E. Adrig

BY Donne, McDougall, Williams & Welsh
Attys

May 28, 1963 V. E. ADRIG 3,091,680

ICE DETECTOR

Filed Oct. 28, 1960 3 Sheets-Sheet 2

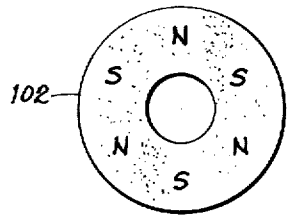


FIG. 4

FIG. 3

INVENTOR.
Vernon E. Adrig
BY Ogma, McDougall, Williams & Herth
Attys

May 28, 1963 V. E. ADRIG 3,091,680

ICE DETECTOR

Filed Oct. 28, 1960 3 Sheets-Sheet 3

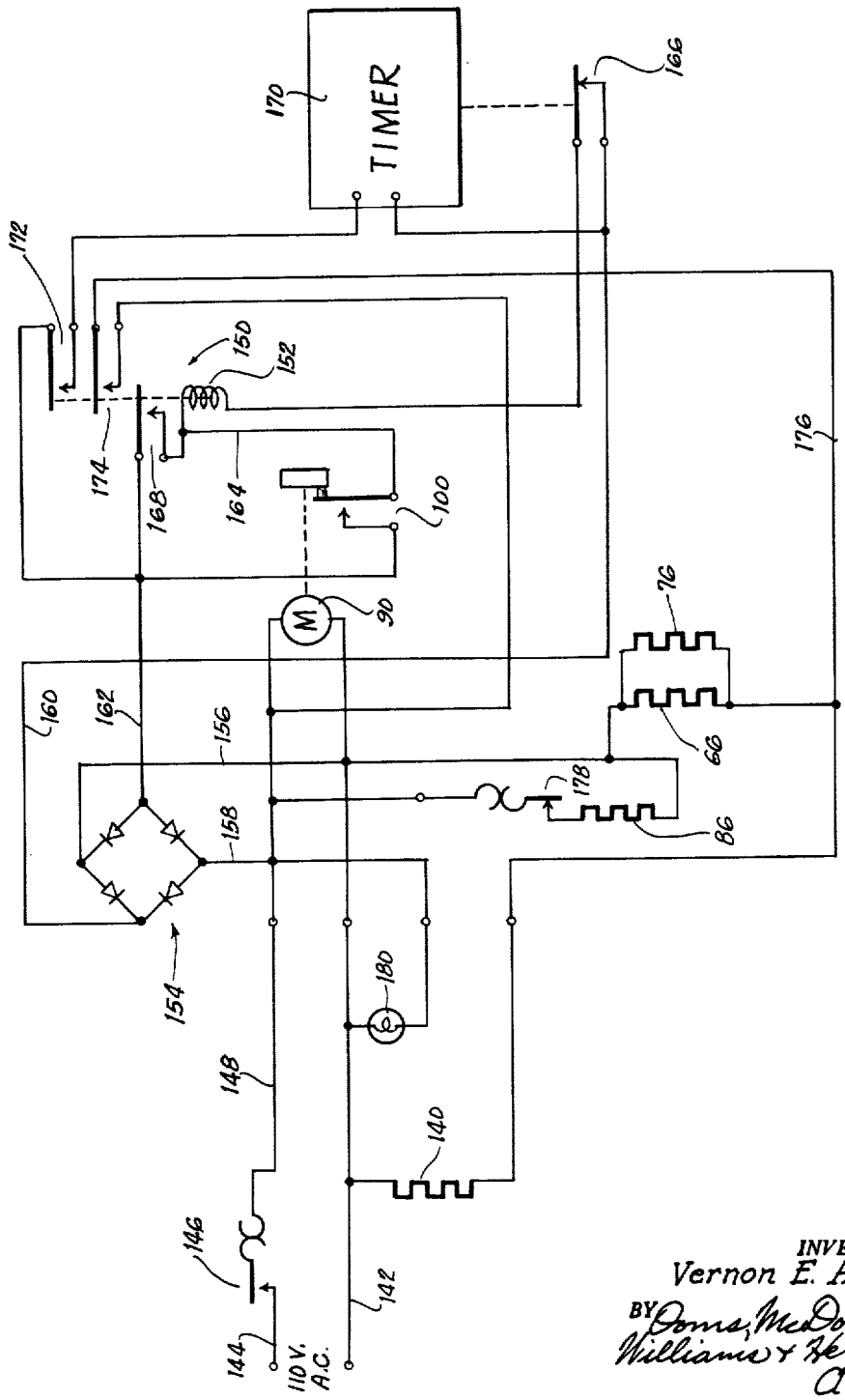


FIG. 5

INVENTOR.
Vernon E. Adrig
BY Dorsey, McDougall, Williams & Hersh
Attys

United States Patent Office 3,091,680 Patented May 28, 1963

3,091,680

ICE DETECTOR

Vernon E. Adrig, West Burlington, Iowa, assignor to Cook Electric Company, Chicago, Ill., a corporation of Delaware

Filed Oct. 28, 1960, Ser. No. 65,624
4 Claims. (Cl. 219—19)

This invention relates to devices for detecting the formation of ice on equipment which is subject to icing conditions, and for energizing a heater which will remove the ice from the equipment so that the ice will not cause the equipment to malfunction. Such ice detectors are valuable for use on outdoor electrical switching gear, for example.

One object of the present invention is to provide a new and improved ice detector which is especially well adapted for use on static or stationary equipment.

A further object is to provide a new and improved ice detector having a moving element which is adapted to be stalled by the formation of ice thereon, the ice detector being provided with means for producing a control signal in response to the stalling of the movable element.

Another object is to provide a new and improved ice detector of the foregoing character in which the moving element takes the form of a rotor driven by a slip clutch, and in which a switch is operated in response to any slipping of the clutch due to the stalling of the rotor by the formation of ice thereon.

A further object is to provide a new and improved ice detector of the foregoing character, in which the slip clutch comprises two magnets, one of which is caused to move toward and away from the other magnet when slippage occurs in the clutch, such movement of the first magnet being employed to operate the switch.

It is another object to provide a new and improved ice detector which is extremely small and compact, yet is highly dependable in operation.

A further object is to provide a new and improved ice detector of the foregoing character, having a heater which is energized for a limited time when the movable element of the ice detector is stalled, so as to free the movable element for another cycle of operation.

Another object is to provide a new and improved ice detector having means for protecting the ice detector itself from moisture and freezing conditions.

Further objects and advantages of the present invention will appear from the following description, taken with the accompanying drawings, in which:

FIG. 1 is a plan view of an ice detector to be described as an illustrative embodiment of the present invention.

FIG. 2 is an elevational view of the ice detector of FIG. 1.

FIG. 3 is an enlarged, somewhat diagrammatic elevational section, taken generally along a line 3—3 in FIG. 1.

FIG. 4 is a plan view of one of the ring-shaped magnets employed in the ice detector.

FIG. 5 is a schematic diagram showing the electrical circuit for the ice detector.

As already indicated, the drawings illustrate an ice detector **10** comprising a probe **12** having a movable element or member **14** and a stationary element or member **16**. The movable member **14** is adapted to move adjacent the stationary member **16**, but is adapted to be stalled by the formation of ice between the members **14** and **16**. In FIG. 2, a coating of ice **18** on the members **14** and **16** is illustrated in broken lines. It will be apparent that the ice **18** will interfere with the movement of the member **14** if the ice becomes sufficiently thick. In this case, the movable member **14** takes the form of a generally hook-

shaped rotor, while the stationary element **16** is in the form of a cylinder or sleeve around which the rotor **14** is movable. The sleeve **16** projects outwardly from a small casing **20** which in turn is mounted on a larger casing **22**. Apertured flanges **24** may be provided on the casing **22** for use in mounting the casing on the equipment to be protected by the ice detector. The smaller casing **20** and the probe **12** may conveniently be arranged to project through an opening in a wall of the equipment to be protected.

As shown to advantage in FIG. 3, the hook-shaped rotor **14** has a straight shaft portion **26** which is rotatable within the stationary sleeve member **16**. The rotor **14** has an arm portion **28** which extends radially from the shaft portion **26** and then doubles back toward the sleeve member **16**. It will be seen that the arm **28** has an end portion **30** which is substantially parallel to the sleeve member **16** and is rotatable in closely spaced relation to the sleeve member. Thus, the formation of a relatively thin layer of ice on the sleeve member or the end portion **30** of the rotor **14** will interfere with rotation of the rotor and thus will tend to stall the rotor.

It will be seen that the sleeve member **16** comprises a cylindrical outer shell **32** which is welded or otherwise secured to the casing **20**. A bushing **34** is received within the shell **32**. It will be seen that the bushing **34** has an enlarged lower portion **36** which is disposed within the casing **20**.

The shaft **26** of the rotor **14** is journalled within the bushing **34**. In the illustrated construction, the lower end of the shaft **26** is screwed into an internally threaded longitudinal bore **38** in a cylindrical shaft extension **40**. A ball-bearing **42** may be provided to support that lower end of the extension **40**. As shown, the ball-bearing **42** is mounted on a pin **44** projecting upwardly from a plate or partition **46** which separates the casing **20** from the casing **22**. By virtue of this arrangement, the rotor **14** is freely rotatable relative to the casing **20**, in the absence of ice between the rotor and the sleeve member **16**.

To exclude moisture from the casing **20**, a rotary shaft seal **48** is provided around the shaft extension **40**. In this case, the seal **48** comprises a rotatable ring **50** which is in rotary sealing engagement with a stationary ring **52**. The ring **50** may be made of metal, while the ring **52** may be made of a material containing graphite, so as to be self-lubricating. A soft rubber or rubbe-like sealing ring **54** is provided between the ring **52** and a cavity or recess **56** in the enlarged portion **36** of the bushing **34**. Similarly, soft rubber-like sealing ring **58** of C-shaped cross section is provided between the ring **50** and a flange member **60** secured to the shaft extension **40**. A compression coil spring **62** provides pressure between the ring **50** and the ring **52**.

An electric heater is provided to melt the ice from the probe **12** so as to free the rotor **14** for another cycle of operation, after the rotor has been stalled by the formation of ice thereon. In this case, the rotor **14** is in the form of a tubular outer shell **64**. An electrical resistance type heating element **66** is received within the tubular shell **64**. The outer end of the heating element **66** may be connected to the shell **64**, which may be made of metal so as to serve as one terminal of the heating element. The shell **64** is grounded to the casing **20** through the bushing **34**.

As shown, the inner end of the heating element **66** is brought out by a lead **68** which may be connected to a slip ring **70** mounted on the flange **60**. As shown, the slip ring **70** is engaged by a brush **72**, which thereby is adapted to supply electrical energy to the heating element **66**. A suitable terminal **74** may extend through the partition **46** into the casing **22** from the brush **72**.

A heating element **76** may also be provided to melt ice

from the sleeve member **16**. As shown, the heating element **76** is mounted in a helical groove **78** formed in the outside of the bushing **34**. One end of the heating element **76** may be grounded, and the other end may be brought out by means of a lead **80** connected to a terminal **82** which extends through the partition **46**. The feed-through terminals **74** and **82** are insulated and hermetically sealed so as to exclude moisture from the casing **22**.

To assist in excluding moisture from the casing **20**, a heating element **86** may be mounted on the inside of the wall of the casing **20**. The heating element **86** may be controlled by a suitable thermostat so as to maintain the temperature within the casing **20** above the freezing point.

An electric motor **90** is provided within the casing **22** for driving the rotor **14**. The motor **90** has a drive shaft **92** which is secured within a longitudinal bore **94** in a drive shaft extension **96**. The motor **90** is preferably provided with self-contained gears (not shown) so that the drive shaft **92** will be rotated at a slow speed, such as twelve revolutions per minute, for example.

The drive shaft extension **96** is coupled to the rotor **14** by means of a slip clutch **98** which delivers only a limited amount of torque to the rotor **14**. Under normal conditions, the torque is sufficient to rotate the rotor **14** without any slipping of the clutch **98**. However, the formation of ice on the rotor **14** or the sleeve member **16** will stall or slow down the rotor **14**, so that the clutch **98** will slip. A switch **100** is arranged to be operated by any slippage of the clutch **98**. Thus, the switch **100** may be connected in an electrical circuit to provide a control signal in response to the formation of ice on the probe **12**. This control signal may be employed to operate a heater or other de-icing equipment for removing the ice from the apparatus protected by the ice detector. The control signal may also be employed to energize the probe heaters **66** and **76** for a limited time, so as to free the rotor **14** for another cycle of operation.

In this case, the slip clutch **98** comprises two permanent magnets **102** and **104**, which are substantially ring-shaped, as shown in FIGS. 3 and 4. The ring-shaped magnets **102** and **104** are magnetized with alternate north and south poles, as indicated in FIG. 4. As shown, the magnet **102** is pressed onto or otherwise secured to the lower end of the rotor shaft extension **40**. The magnet **104** is pressed into or otherwise secured in a circular recess or bore **106** formed in a flange **108** which extends outwardly from a supporting member or hub **110**. In this case, the hub **110** is formed with a bore **112** which is slidably received over the drive shaft extension **96**. A pin **114** is provided to connect the hub **110** to the drive shaft extension **96** so that the hub will rotate with the drive shaft extension. However, the pin **114** is slidably received in a longitudinal slot **116** in the extension **96**, so that the hub **110** will be free to slide back and forth through a limited range along the extension **96**.

It will be seen that the magnets **102** and **104** are on opposite sides of the partition **46** between the casings **20** and **22**. Torque is transmitted between the magnets **104** and **102** by virtue of the magnetic field between the magnets. When the rotor **14** is free to rotate, the magnets **102** and **104** align themselves so that magnetic poles of opposite polarity are opposite each other on the two magnets. Thus the magnets **102** and **104** are strongly attracted to each other so that no slippage occurs between the magnets. Moreover, the magnet **104** is attracted toward the magnet **102**, so that the magnet **104** is held against sliding movement along the drive shaft extension **96**.

When the rotor **14** is slowed down or stalled by the formation of ice between the rotor and the sleeve member **16**, slippage occurs between the magnets **102** and **104**. The slippage causes alternate attraction and repulsion between the magnets **102** and **104**, as the poles of the magnet **104** move past the poles of the magnet **102**. Thus, the magnet **104** and the hub **110** are moved back and forth along the shaft extension **96**.

It will be seen that the control switch **100** comprises a pair of normally open contacts **120** and **122** which are mounted on spring arms **124** and **126**. An operating arm **128** is also provided to close the contacts **120** and **122** when the hub **110** is moved back along the shaft extension **96** by the repulsion between the magnets **102** and **104**. The arm **128** has an end portion **130** which is engageable by the flange **108** on which the magnet **104** is mounted. Thus, the switch **100** is closed when slippage occurs between the magnets **102** and **104** of the slip clutch **98**. The closure of the switch **100** indicates that ice has formed on the rotor **14** to an extent sufficient to stall the rotor.

As already indicated, the closure of the switch **100** may be employed to produce a signal which energizes the probe heaters **66** and **76** for a limited time, so as to free the rotor **14** for rotation, so that the ice detector will go through another cycle of operation. The ice detector is also arranged to supply an output signal of a particular duration which can be used to energize heaters, relays or other equipment. Thus, the detector may be employed to energize an external heater **140** or other deicing apparatus adapted to remove the ice from the equipment protected by the ice detector. These functions may be carried out by the electrical arrangement shown in FIG. 5.

The ice detector may be energized by alternating current received from a pair of power lines **142** and **144**. The alternating current may be at 110 volts and 60 cycles, or any other suitable voltage and frequency. A thermostatic switch **146** may be employed to start the ice detector when the atmospheric temperature drops to such an extent that icing conditions can occur. The thermostatic switch **146** is effective to shut down the ice detector when the atmospheric temperature rises to a level such that icing conditions cannot occur. It will be seen that the thermostatic switch **146** is connected between the power line **144** and a lead **148**. The drive motor **90** is connected directly between the leads **142** and **148**, so that the drive motor is energized whenever the thermostatic switch **146** is closed.

The switch **100** may be employed to operate a relay **150** having a coil or winding **152**. Direct current to operate the relay **150** may be provided by a full wave rectifier **154** having input leads **156** and **158** connected to the alternating current power leads **142** and **148**. The direct current from the rectifier **154** may be delivered across direct current power leads **160** and **162**. It will be seen that the control switch **100** is connected between the direct current lead **162** and a lead **164** extending to one side of the relay coil **152**. The other side of the relay coil **152** is connected to the direct current power lead **160** by a normally closed timer switch **166**. Thus, the closure of the control switch **100** energizes the relay coil **152**.

To maintain the energization of the relay coil **152**, the relay **150** is provided with a pair of holding contacts **168** which are connected across the switch **100**. The holding contacts **168** are normally open but are closed when the relay coil **152** is energized. This completes a holding circuit which bypasses the switch **100**, so that the relay coil **152** will continue to be energized, even if the switch **100** is opened. The energization of the relay coil **152** continues until the timer switch **166** is opened by a timer **170**.

The timer **170** may be of any known or suitable type, and is adapted to be energized or started by the closure of another pair of normally open contacts **172** on the relay **150**. One side of the timer **170** is connected to the direct current power lead **160**, while the other side of the timer is connected to the power lead **162** through the contacts **172**. After being energized for a predetermined interval, the timer **170** opens the switch **166** and thereby de-energizes the relay coil **152**. The relay coil **152** will

remain de-energized until the control switch **100** is again closed.

The relay **150** has a third pair of normally open contacts **174** which control the energization of the probe heaters **66** and **76** and the external de-icing heater **140**. Thus, one side of the heater **140** is connected to the alternating current power line **142**. This is also true of one side of each of the probe heaters **66** and **76**. Thus, the heaters **66**, **76** and **140** are connected in parallel between the lead **176** and the alternating current power line **142**. The contacts **174** are connected between the lead **176** and the alternating current power lead **148**. Thus, closure of the contacts **174** energizes the heaters **66**, **76** and **140**.

The casing heater **86** is connected in series with a thermostatic switch **178** across the alternating current power leads **142** and **148**. The thermostatic switch **178** maintains the temperature inside the casing **20** above the freezing point so that the operation of the ice detector will not be impaired by any moisture that may penetrate into the casing **20**.

In operation, the rotor or vane **14** is normally rotated by the magnetic attraction between the permanent magnets **102** and **104** of the slip clutch **98**. The permanent magnet **104** is continuously rotated by the motor **90** at a low speed. When ice forms to a sufficient thickness on the rotor **14** or the sleeve member **16**, the rotor will be slowed down or stalled so that slippage will occur between the permanent magnets **102** and **104**. As a result, the permanent magnet **104** and its mounting hub **110** will be slid back and forth along the shaft extension **96** by the alternate repulsion and attraction between the magnets **102** and **104**, as the poles on the magnets move past one another. As the magnet **104** moves away from the magnet **102**, the flange **108** engages the switch operating arm **128** and closes the contacts **120** and **122** of the switch **100**. Thus, the closure of the switch **100** indicates that ice has formed on the probe members **14** and **16** of the ice detector.

The closure of the switch **100** energizes the relay **150**, which in turn energizes the timer **170**. The energization of the relay **150** is maintained by the holding contacts **168** on the relay. The contacts **174** of the relay energize the probe heaters **66** and **76** and the external de-icing heater **140**. After a limited time, the timer **170** opens the switch **166** so as to de-energize the relay **150**. If the switch **100** is still closed, the relay **150** will again be energized, and the timer **170** will go through another cycle.

The heat generated by the probe heaters **66** and **76** melts the ice from the rotor **14** and the stationary sleeve **16**. When the ice has been melted sufficiently to free the rotor **14**, the slip clutch **98** will again rotate the rotor without any slippage in the clutch. Thus, the switch **100** will be opened. The rotor **14** will continue to rotate until it is again stalled by the formation of ice on the rotor or the sleeve member **16**.

The external heater **140** may be located so as to melt the ice from the equipment which is protected by the ice detector. It will be apparent that the ice detector energizes the heater **140** only when icing conditions exist. Thus, the consumption of electrical power by the heater **140** is minimized.

A pilot lamp **180** may be connected between the alternating current power leads **142** and **148** to indicate when the ice detector is turned on by the thermostatic switch **146**. When the atmospheric temperature is above the level at which icing conditions can occur, the thermostatic switch **146** turns off the ice detector.

It will be apparent that the ice detector is effective in operation and extremely compact. Nevertheless it is low in cost and economical to operate.

Various modifications, alternative constructions and equivalents may be employed without departing from the true spirit and scope of the invention, as exemplified in the foregoing description and defined in the following claims.

I claim:

1. In an ice detector, the combination comprising a probe having a stationary sleeve member, said probe comprising a rotary member having a shaft portion rotatable within said stationary sleeve member, said rotary member having a generally hook-shaped arm portion extending outwardly from said shaft portion and rotatable adjacent the outside of said sleeve member, said arm portion being adapted to be stalled by the formation of ice between said arm portion and said sleeve member, a magnetic slip clutch for driving said rotatable member, said clutch comprising a first permanent magnet mounted on said rotary member, a drive shaft, and a second permanent magnet adjacent said first permanent magnet and mounted on said drive shaft for rotation therewith and for limited axial sliding movement thereon, a motor for continuously rotating said drive shaft, a switch operable by sliding movement of said second permanent magnet relative to said drive shaft, said second permanent magnet being attracted toward said first permanent magnet and thus being held against sliding movement along said drive shaft as long as said rotary member is rotating, said second permanent magnet being caused to slide back and forth along said drive shaft by the alternate repulsion and attraction between said permanent magnets when said rotary member is stalled, an electric heater for heating said probe to remove ice therefrom, and means operable by said switch for energizing said electric heater for a predetermined interval so that said rotary member will be freed of ice after being stalled.

2. In an ice detector, the combination comprising a stationary probe member, a rotary probe member rotatable adjacent said stationary probe member and adapted to be installed by the formation of ice between said members, a motor, a slip clutch connected between said motor and said rotary probe member, a switch operable in response to slipping of said clutch when said rotary probe member is stalled, a heater for melting ice from said probe members, and means operable by said switch for energizing said heater for a limited time so as to free said rotary probe member from ice after being stalled.

3. In an ice detector, the combination comprising a stationary probe member, a hook-shaped rotor rotatable adjacent said stationary member, a heater within said rotor, a drive shaft, a motor for continuously rotating said drive shaft, a slip clutch connected between said drive shaft and said rotor for rotating said rotor with a limited torque, said rotor thereby being adapted to be stalled by the formation of ice between said rotor and said stationary member, said slip clutch comprising a first magnet carried by said rotor and a second magnet on said drive shaft, means mounting said second magnet on said drive shaft for rotation therewith and limited sliding movement along said drive shaft, said second magnet being attracted toward said first magnet and thereby being held against sliding movement as long as said rotor is being driven without slippage by said clutch, said second magnet being slid back and forth along said drive shaft by the alternate repulsion and attraction of said magnets when slippage occurs between said magnets, a switch operable by the sliding movement of said second magnet, and means operable by said switch for energizing said heater in said rotor for a limited time to melt the ice from said rotor and thereby free said rotor for another cycle of operation.

4. In an ice detector, the combination comprising a stationary probe member, a rotor rotatable adjacent said stationary member, a drive shaft, a motor for continuously rotating said drive shaft, a slip clutch connected between said drive shaft and said rotor for rotating said rotor with a limited torque, said rotor thereby being adapted to be stalled by the formation of ice between said

rotor and said stationary member, said slip clutch comprising a first magnet carried by said rotor and a second magnet on said drive shaft, means mounting said second magnet on said drive shaft for rotation therewith and limited sliding movement along said drive shaft, said second magnet being attracted toward said first magnet and thereby being held against sliding movement as long as said rotor is being driven without slippage by said clutch, said second magnet being slid back and forth along said drive shaft by the alternate repulsion and attraction of said magnets when slippage occurs between said magnets, and a switch operable by the sliding movement of said second magnet.

References Cited in the file of this patent

UNITED STATES PATENTS

2,352,830	Ford	July 4, 1944
2,506,886	Okulitch et al.	May 9, 1950
2,521,723	Hubbell	Sept. 12, 1950
2,566,743	Okulitch et al.	Sept. 4, 1951
2,864,927	Veldhuis	Dec. 16, 1958

FOREIGN PATENTS

506,843	Great Britain	June 6, 1939
936,651	France	Feb. 23, 1948