United States Patent

McCarty

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[54] **MONITOR CIRCUIT FOR VACUUM-TYPE ELECTRIC CIRCUIT INTERRUPTER**

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[56] **References Cited**

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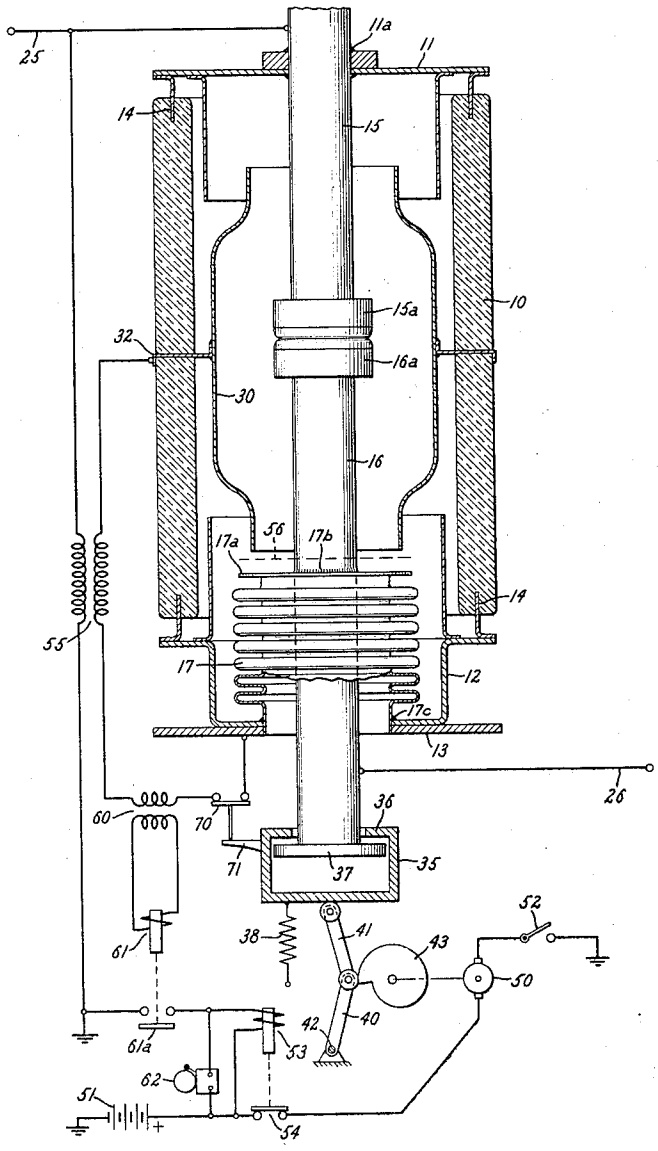
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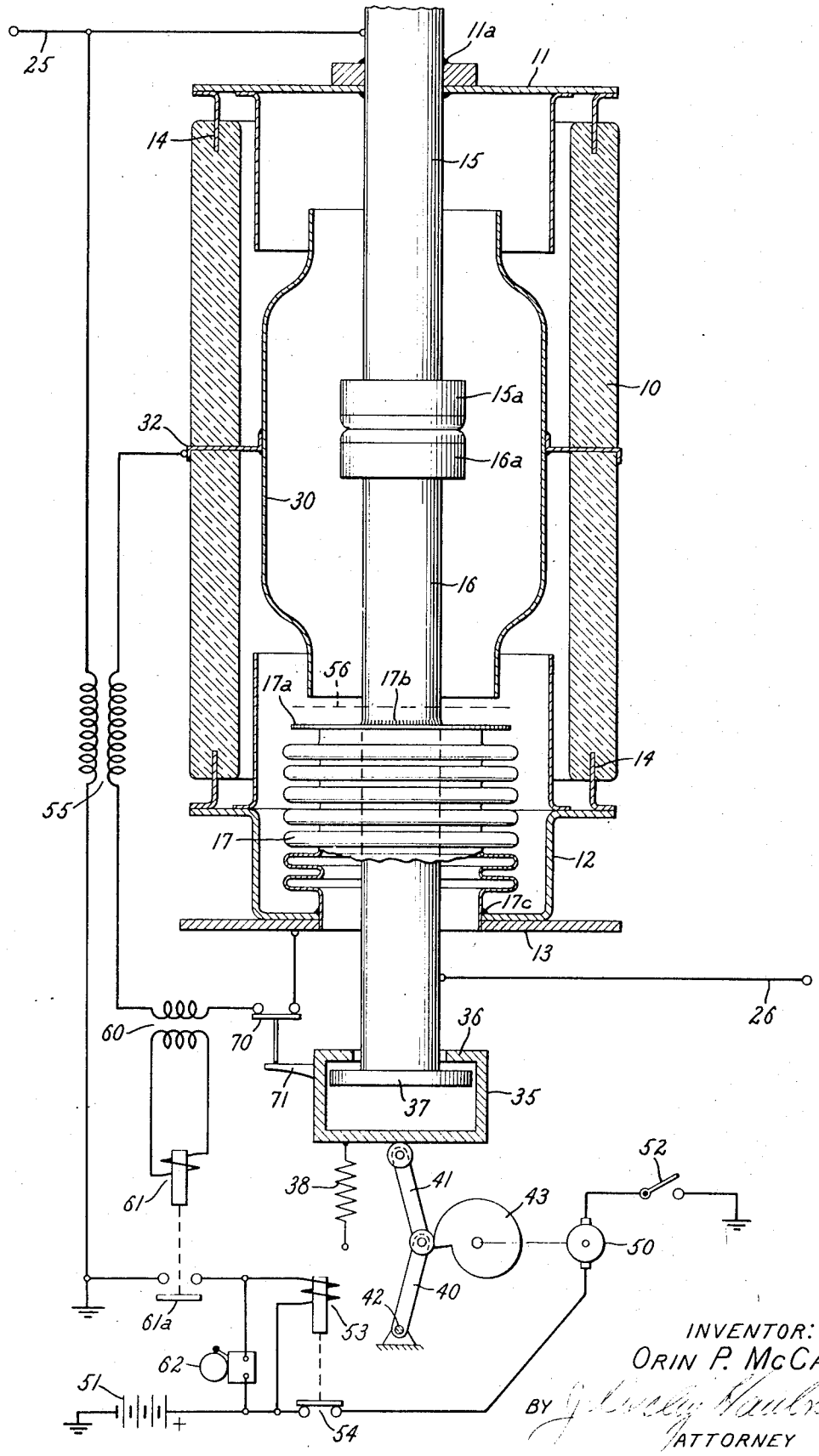
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[57] **ABSTRACT**

This application discloses a protective circuit for monitoring both loss of vacuum and contact wear in a vacuum-type electric circuit interrupter having separable contacts and a vapor shield surrounding the contacts. The shield is so located that a part fixed to the moving contact rod and normally spaced from the shield will closely approach or engage the shield as a result of contact wear. A monitor circuit including the rod-to-shield gap includes current responsive indication or control means.

8 Claims, 1 Drawing Figure





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MONITOR CIRCUIT FOR VACUUM-TYPE ELECTRIC CIRCUIT INTERRUPTER

My invention relates to means for monitoring vapor pressure and contact wear inside a vacuum-type electric circuit interrupter, and particularly to current responsive means for substantially continuously monitoring both pressure and contact wear while the interrupter is connected for service in a high voltage power circuit.

As illustrated in U.S. Pat. No. 3,472,981 to McCarty it has been proposed to utilize vacuum interrupting devices as the normally closed arcing contactor in stepping-type load tap changers for power transformers, reactors and the like. In such service the arcing contact device is ordinarily immersed in a dielectric fluid and is subject to highly repetitive current interrupting operation. It is therefore most desirable to monitor such a device for fluid leaks and for contact wear by means operable substantially continuously and not requiring interruption of service or other irregular inspection procedure.

Accordingly it is a principal object of my invention to provide simple and inexpensive protective means for substantially continuously monitoring either internal pressure or contact wear or both in a vacuum-type electric circuit interrupter.

It is a further object of my invention to provide common current responsive means external to a vacuum-type circuit interrupting device for simultaneously and substantially continuously monitoring both internal pressure and contact wear.

A typical vacuum-type circuit interrupter comprises a highly evacuated envelope and a pair of relatively movable contacts located within the envelope. When the interrupter is in closed circuit position the contacts are engaged and are thus capable of carrying current through the interrupter. Circuit interruption is effected by separating the contacts to draw an arc therebetween, and when extinguished the arc is prevented from reigniting because of the existing vacuum within the envelope. To ensure that the arc will be extinguished as desired and prevented from reigniting, it is important that the pressure inside the envelope be maintained below a predetermined value and that contact wear be limited to a predetermined maximum.

In carrying out my invention in one preferred embodiment, I utilize a vacuum interrupting device having a pair of contact rods axially aligned for abutting engagement within an evacuated envelope of insulating material. One rod is fixedly mounted and the other is axially movable to engage and disengage contacts at the abutting ends of the rods. The movable rod is sealed to the evacuated envelope through a concentric flexible bellows having one end fixed to the rod. A tubular metallic shield is positioned within the envelope and surrounding the separable contacts. The shield is mounted in an insulating support for electrical isolation from the contacts and extends at one end into proximity with a lateral projection on the moving contact. The movable end of the flexible bellows serves conveniently as such a projection. Gradual erosion of the contacts diminishes the gap between shield and bellows in the contact engaging position of the bellows. The gap is initially so set that it will be reduced to zero or other predetermined minimum dimension after a predetermined maximum permissible amount of contact wear. To provide a signal for alarm or protective action when the gap attains its minimum dimension it is connected in an electric circuit as a discharge gap or contact switch or both. The potential impressed across the gap is preferably so selected that a predetermined loss of pressure in the envelope, as well as a predetermined diminution of the gap, will permit current to flow from bellows to shield and actuate an alarm or protective device in the circuit.

My invention will be more fully understood and its objects and advantages further appreciated by referring now to the following detailed specification taken in conjunction with the accompanying drawing, the single FIGURE of which is a schematic illustration of a vacuum-type circuit interrupting device shown in axial cross section and including a protective monitor circuit in accordance with my invention.

Referring now to the drawing, I have shown a vacuum-type circuit interrupter which comprises a highly evacuated housing or envelope formed of a tubular insulating shell **10** and a pair of metallic end caps **11** and **12**. The end caps **11** and **12** are connected to the tubular shell **10** by hermetic seals **14** and each cap is centrally apertured to permit passage through the cap of a current carrying contact rod. The cap **12** is seated upon a metallic mounting plate **13**.

Within the evacuated envelope **10, 11, 12**, a pair of contact rods **15** and **16** are positioned in axial alignment and provided, respectively, with separable abutting disk-shaped contacts **15***a* and **16***a*. The contact rod **15** enters the envelope through a central aperture in end cap **11** and is fixedly mounted on that end cap as by the welds **11***a*. The contact rod **16** passes through aligned aperture in end cap **12** and plate **13** and is mounted for axial sliding movement between contact engaging and disengaging positions. In the drawing the contacts **15***a* and **16***a* are shown in engaged position and it will be understood by those skilled in the art that when the movable contact rod **16** is moved downwardly, as shown in the drawing, the contacts will separably be disengaged. To seal the movable contact rod **16** to the end cap **12** a flexible metallic bellows **17** of generally tubular configuration surrounds the contact rod **16**. The bellows **17** is closed at its upper end by a disklike base portion **17***a* which is hermetically sealed to rod **16** by a weld **17***b*. The open lower end of bellows **17** is sealed to the end cap **12** by a weld **17***c*. Because the bellows **17** forms a wall portion of the evacuated envelope the pressure difference between its inner and outer surfaces normally expends the bellows and biases the contact rod **16** to its contact engaging position.

The primary function of the vacuum interrupter is to control the flow of an electric current through a high voltage power circuit in which it is connected. Such a circuit is represented by a conductor **25** shown connected to the fixed contact rod **15** and a conductor **26** connected to the movable contact rod **16**. When the contacts **15***a* and **16***a* are in engaged position as shown, current can flow between the conductors **25** and **26** through the contact rods **15** and **16**.

In order to interrupt the circuit between the conductors **25** and **26** the movable contact rod **16** is driven downwardly against its bias to separate the contacts **15***a*, **16***a*. Contact separation establishes an arc between the contacts which arc persists until the first natural current zero, assuming an alternating current circuit. The arc is prevented from reigniting after current zero by the high dielectric strength of the vacuum within the envelope thereby completing circuit interruption.

For condensing the metallic vapors which are liberated from the contacts by arcing, a tubular metal shield **30** is provided. Metal vapors projected by the arc from the gap between the contacts **15***a*, **16***a* are intercepted and quickly condensed by this shield **30** during an interrupter operation. During an interrupter operation, as will be explained hereinafter, the metal shield **30** is electrically isolated from both contacts **15** and **16**. The shield **30** is suitably mounted upon an annular metal ring **32** which is hermetically sealed in and extends through the insulating shell **10** of the evacuated envelope.

The annular shield **30** is so positioned that its lower end is adjacent but axially spaced from the disklike base **17***a* of bellows **17**. Since the base **17***a* of bellows **17** is fixed to and extends laterally from the movable contact rod the gap between shield and bellows base is variable. This gap is minimum when the contacts **15***a*, **16***a* are engaged, as shown, and diminishes gradually to a limiting small dimension (which may be zero) as the interrupter contacts wear or erode. The shield **30** is so positioned that as a limit it will be engaged to the laterally projecting base end **17***a* of bellows **17**.

In the drawing I have illustrated schematically a suitable actuating mechanism for moving the contact rod **16** between engaging and disengaging position with respect to the contact rod **15**. As previously noted, because of the high degree of vacuum within the envelope i.e., on the outer surface of the

flexible bellows **17**, and the presence of normal atmospheric pressure within the bellows **17** the contact rod **16** is biased into contact engaging position by the pressure difference between the inside and the outside of the bellows. It will of course be understood that if desired this bias may be supplemented or reversed by the addition of suitable springs or the like. In the illustrated embodiment no bias is provided other than the closing bias of bellows **17**.

In order to drive the contact rod **16** to contact disengaging position against its bias I have shown at the lower end of the rod a slidable actuating member **35** loosely connected to the rod **16** by interengaging annular shoulders **36** and **37** and biased to contact opening position by a driving spring **38**. To move the actuating member **35** against its bias and thereby permit the movable contact rod **16** to move to engaging position under its own bias I provide a toggle **40, 41** positioned between the actuating member **35** and a fixed pivot **42**. The toggle **40, 41** is driven to extended position (as shown) by a rotatable cam **43**. As shown the cam **43** is so shaped that a slight further clockwise movement suddenly releases the prop **40, 41** for collapse by the driving spring **38**. For opening and closing operation of the vacuum interrupter I have shown the cam **43** driven by a motor **50** which is energized from a suitable source of control power, shown as a battery **51**, and normally controlled by a switch **52**. For a purpose to be described hereinafter the motor **50** may be disabled and operation of the vacuum interrupter prevented by actuation of a relay **53** having normally closed contacts **54** in series circuit relation in the motor circuit.

It will of course be evident to those skilled in the art that if desired other switch actuating mechanisms may be used, but I find it especially desirable in the application of my invention to use an overtravel type actuator, such as the member **35**, which begins its opening movement prior to movement of the movable contact.

When a vacuum interrupter is utilized as the arcing contactor in a transformer load tap changing apparatus, such as that shown in U.S. Pat. No. 3,472,981 to McCarty et al., it is normally subjected to very frequent opening and closing operation and may be located in a hazardous atmosphere, as by immersion in oil. As pointed out in the McCarty et al. patent such oil-immersed location makes it advisable that the internal pressure in the evacuated envelope be monitored substantially continuously to detect any abnormal pressure increase. The high operating frequency of tap changing duty makes it further desirable that automatic mean be provided for indicating or responding to excessive contact erosion. In some applications it is desirable to disable the vacuum interrupting device in response to contact wear of a predetermined maximum amount.

In order to provide automatic monitoring of both of the foregoing conditions I apply across the variable gap between the movable end of flexible bellows **17** and the proximate end of metallic shield **30** a high potential derived through a transformer **55** having a primary winding connected to the power circuit conductor **25** and a secondary winding connected between the shield supporting ring **32** and the mounting plate **13**. The potential applied across the shield-to-bellows gap must be sufficiently low so that no significant discharge is present across minimum gap spacing greater than the minimum limit so long as pressure inside the evacuated envelope is in a normal range, but sufficiently high to initiate a discharge across even the maximum gap spacing when the pressure inside the envelope is above the normal range. By way of example, such a monitoring voltage may suitably be of the order of 5,000 volts.

It is likely that with monitoring voltage sufficiently high to monitor internal pressure discharge across the shield-to-bellows gap (as its minimum is reduced by contact wear) will occur at some limiting distance prior to actual engagement of these parts, as for example when the movable end of the bellows in its contact closing position progresses by contact wear to the position shown by the dotted line **56**. If desired, of course, the monitoring voltage may be sufficiently low to require engagement between the shield and bellows before the secondary winding of transformer **55** conducts current. Such lower voltage is appropriate if it is desired to monitor only contact wear and not loss of vacuum. In this case the monitoring voltage may be from any available source of control voltage and may be alternating or unidirectional.

While I have shown the movable end of bellows **17** as one terminal of the monitor gap, it will be evident to those skilled in the art that any suitable electrically conductive lateral extension on the movable contact rod **16** may be utilized for this purpose.

In order to indicate flow of signal current in the secondary winding of the monitoring transformer **55** I have shown the secondary connected to supply current through a transformer **60** to a normally open contrOl relay **61**. The contacts **61*a*** of relay **61** are connected to complete a circuit from the control power source **51** to an alarm device, shown as a bell **62**, and to a protective device, shown as the motor disabling relay **53**. It will be evident that the signal current may be utilized as desired, for either indication or control, or both. With the relay **53** shown by way of example it will be evident that energization of the relay will open the circuit of motor **50** and prevent further actuation of the interrupter contact **16**.

It is important to the operation of some vacuum interrupting devices that the metallic shield **30** be electrically isolated from the contact **15*a***, **16*a***, at least during circuit interrupting operation. To ensure such isolation I have provided a control switch **70** in the secondary clrcuit of the monitoring transformer **55**. The switch **70** is biased to open position but normally held closed by a portion **71** of the actuating member **35** when in the contact closing position shown. It will be evident that when the member **35** is released to open the vacuum interrupter contacts the control switch **70** will be opened before the vacuum interrupter contacts **15*a***, **16*a*** are separated. Thus the monitor voltage between the shield **30** and contact rod **16** is removed before an arc is drawn and during interruption the shield is electrically isolated from the interrupter contacts. A monitoring circuit of this type is more fully described and is claimed in U.S. Pat. No. 3,403,297 to Crouch.

It will now be observed that in operation monitoring voltage from the secondary winding of the transformer **55** is applied across the bellows-to-shield gap inside the vacuum interrupter envelope at all times when the interrupter contacts are in engagement. Thus in all circuit applications where the interrupter is used as a normally closed switching device, as in power circuit breaker applications and in load tap changing apparatus of the type previously referred to, my single monitoring circuit, which includes the bellows-to-shield gap within the interrupter envelope, serves to monitor substantially continuously both loss of vacuum and contact wear. If in any particular application it is desired to utilize this circuit only for monitoring contact wear it is possible to utilize a low monitor voltage and to set the initial shield-to-bellows gap so that contacting engagement between the shield and the bellows is necessary to initiate the flow of signal current in the monitor circuit.

While I have shown and described a particular embodiment of my invention by way of illustration, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from my invention in its broader aspects; I therefore, intend in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In a protective system for a vacuum-type electric circuit interrupter comprising an evacuated envelope having cooperable fixed and movable contacts therein, a movable contact rod carrying said fixed contact and extending through the wall of said envelope, said rod being slidable axially between contact engaging and disengaging positions, a tubular metal shield fixedly mounted within said envelope and sur-

rounding said contacts, said shield being mounted for electrical isolation from said contacts, an electrically conductive projection on said movable contact rod adjacent but axially spaced from one end of said shield, the gap between said shield and said projection being minimum when said contact rod is in its contact engaging position, said minimum gap diminishing as said contacts erode in current interrupting operation, means for impressing an electric potential across said gap, and signal means responsive to flow of current between said shield and projection for substantially continuously monitoring contact wear and vacuum sealing in said circuit interrupter.

2. In a protective system for a vacuum-type electric circuit interrupter comprising an evacuated envelope having cooperable fixed and movable contacts therein, a movable contact rod carrying said fixed contact and extending through the wall of said envelope, said rod being slidable axially between contact engaging and disengaging positions, a tubular metal bellows closed at one end and surrounding said rod, said bellows having said one end hermetically sealed to said rod and its other end sealed to said wall, a tubular metal shield fixedly mounted within said envelope and surrounding said contacts, said shield being mounted for electrical isolation from said contacts, said one end of said bellows being adjacent but axially spaced from one end of said shield and movable with said contact rod so that the variable gap from bellows to shield is minimum when said contact rod is in contact engaging position, said minimum gap diminishing as said contacts erode in current interrupting operation, and single means for substantially continuously monitoring contact wear and vacuum sealing in said circuit interrupter comprising means for applying an electric potential across said gap.

3. In a protective system for a vacuum-type electric circuit interrupter comprising an evacuated envelope having cooperable fixed and movable contacts therein, a movable contact rod carrying said fixed contact and extending through the wall of said envelope, said rod being slidable axially between contact engaging and disengaging positions, a tubular metal bellows surrounding said rod and having a disklike closure at one end, said bellows being hermetically sealed at its closed end to said rod and at its other end to said wall, a tubular metal shield fixedly mounted within envelope and surrounding said contacts, said shield being mounted for electrical isolation from said contacts, said closed end of said bellows being adjacent but axially spaced from one end of said shield and movable with said contact rod so that the variable gap from bellows to shield is minimum when said contact rod is in contact engaging position, said minimum gap diminishing as said contacts erode in current interrupting operation, means for applying an electric potential across said gap when said contacts are engaged, and means for removing said electric potential during separation of said contacts.

4. The apparatus of claim 3 in combination with means biasing said contact rod to contact engaging position, lost motion actuating means for disengaging said contacts including a driving member movable prior to contact separation, said means for removing electric potential being actuated by said driving member prior to contact separation.

5. The apparatus of claim 3 wherein said electric potential is sufficiently low that no significant discharge is present across said minimum gap when greater than a predetermined limiting dimension and the pressure inside said envelope is in a normal range, said potential being sufficiently high that discharge across said gap will occur at its maximum dimension when said pressure is above said normal range, and signal means connected in series circuit relation with said gap and operable in response to flow of current between said shield and bellows.

6. The apparatus of claim 4 in combination with said signal means includes means responsive to flow of current across said gap for disabling said actuating means.

7. The apparatus of claim 2 in combination with signal means operable in response to flow of current between said shield and bellows.

8. In a protective system for a vacuum-type electric circuit interrupter comprising an evacuated envelope having cooperable fixed and movable contacts therein, a movable contact rod carrying said fixed contact and extending through the wall of said envelope, said rod being slidable axially between contact engaging and disengaging positions, a conductive lateral projection on said movable contact rod, a tubular metal shield fixedly mounted with said envelope and surrounding said contacts, said shield being mounted for electrical isolation from said contacts, said lateral projection being normally spaced from one end of said shield to provide a gap between said shield and projection which is a minimum when said movable contact rod is in contact engaging position, said gap diminishing by wear as said contacts erode in current interrupting operation and said projection being positioned at the limit of such wear to engage said shield, current responsive signal means, and means operable upon engagement of said shield and projection to energize said signal means.

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