May 24, 1960 E. B. CANFIELD 2,938,091

ELECTROMECHANICAL OVERSPEED LIMIT SWITCH

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Fig. 2.

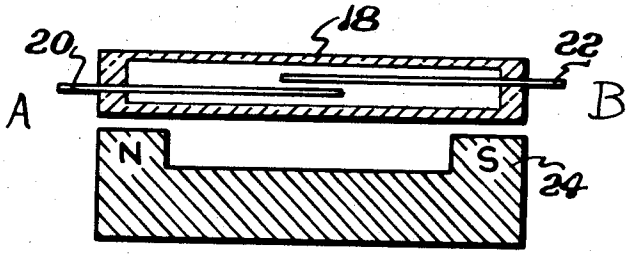


Fig. 3.

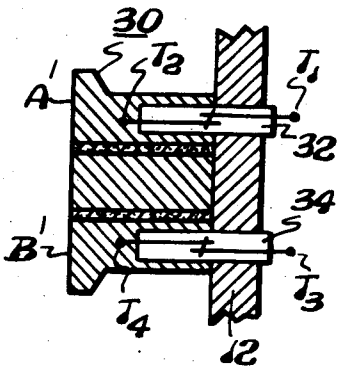
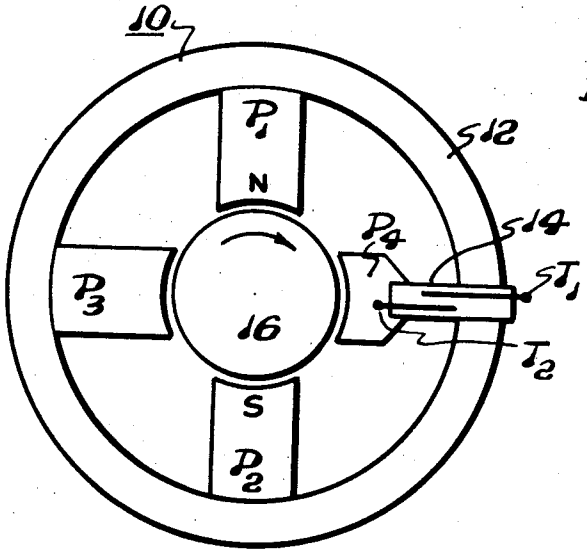


Fig. 1.



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ELECTROMECHANICAL OVERSPEED LIMIT SWITCH

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The present invention relates to an electromechanical limit switch and more particularly to an electromechanical overspeed limit switch operative on a small amount of magnetic flux and unaffected by forces due to gravity, linear acceleration, and the like.

It is general knowledge, that a large number of present day speed limit switches are, in most cases, complex arrangements of springs and levers closing a switch through the medium of centrifugal force and, usually, require slip rings to transmit the information from a rotating element inherent therein. In addition to the complexity of structural details these switches have a somewhat dubious reliability under some conditions of operation. For example, a centrifugal overspeed switch is affected by forces due to gravity and linear acceleration, which decreases its operational efficiency.

The present invention provides an electromechanical overspeed limit switch which reduces the number of parts usually associated with present limit switches, eliminates the necessity of a commonly used slip ring assembly and reduces the cost of manufacture and maintenance while permitting considerable increase in reliability of operation. Basically, the present invention discloses a switch closure which is a function of armature reaction so that a simple and reliable switch closure or opening is obtained as a function of speed. Hence, the present invention comprises a switch which operates on a small amount of magnetic flux, and when the magnetic intensity becomes sufficiently great, a pair of metallic switch leads become oppositely magnetized and the two leads attract each other to complete the circuit. It will be obvious, of course, that a switch can be constructed, in accordance with the principles of the present invention, so that the switch can be open if desired as a function of the speed.

An object of the present invention is the provision of an electromechanical limit switch which is operative as a function of speed.

Another object is to provide an electromechanical limit switch with a switch closure as a function of armature reaction.

A further object of the invention is the provision of an electromechanical overspeed limit switch operative as a function of armature reaction which controls the switch on a small amount of magnetic flux.

The attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings in which like reference numerals designate like parts throughout the figures thereof and wherein:

Figure 1 is a plan view of a preferred embodiment of the invention;

Figure 2 is a sectional view of the type of switch utilized in the preferred embodiment of Figure 1; and

Figure 3 is a sectional view of a modification of the preferred embodiment of Figure 1, wherein the switch

is normally closed and opens when the desired speed is obtained.

Referring now to the drawings, there is illustrated a preferred embodiment **10** illustrating a basic form of a limit switch, comprising a pair of permanent magnet field poles P_1 and P_2 connected to a soft iron field yoke **12**, by any conventional securing means, and constructed in a manner similar to field poles used in a conventional D.C. motor. Approximately ninety electrical degrees from the main field poles, P_1 and P_2, and approximately ninety mechanical degrees in the case of a two pole machine, are mounted cross field pole P_3 and a switch **14**, to be disclosed hereinafter, suitably provided with a pickup shoe P_4 and with conventional type leads T_1 and T_2.

A rotor **16** is concentrically provided with respect to the field yoke **12**, the main and cross field poles P_1 through P_3, and the pickup shoe P_4. The rotor may be a conventional squirrel cage rotor similar to that used in induction motors and frequently provided with aluminum conductors integrally mounted into the slots provided therein. It is understood, of course, that the structural dimensions of the various elements utilized in the structure embodying the present invention are a function of the specific electrical and magnetic values required to perform a predetermined switching task for a specific installation.

Figure 2 shows the salient details of the switch **14** which comprises a glass envelope **18** internally provided with a number of substantially parallel contact leaves **20** and **22** supported therein in such manner that the respective ends of the leaves protrude from opposite ends of the glass envelope. The leaves **20** and **22** are made of magnetic material and of suitable dimension to have sufficient resiliency to perform their predetermined function. The two parallel leaves are supported within the glass envelope **18** so that their respective interior ends are overlapped and spaced a predetermined amount, depending on the particular installation and use intended. Switches, such as switch **14**, are commercially available for use in the present invention. Therefore, the particular or specific construction of these switches do not form part of the present invention; however, the application of these switches and the particular method of combining the switches with the other structure of the present invention, is considered the subject matter of the invention.

A magnet **24** is illustrated in Figure 2, in conjunction with the switch **18** merely to illustrate the normal operation of the switch. Hence, when the magnet **24** is brought into proximity of the switch **18**, and one leaf is magnetized by one pole of the magnet and the other leaf magnetized by the other pole, the two parallel and resilient leaves attract each other. When the magnetic intensity becomes sufficiently great, the leaves spring together to complete an electric circuit through the switch **18** between the illustrated points A and B. In this manner, the switch is simply a switch which operates on a small and predeterminable amount of magnetic flux.

In the operation of the present invention, the main field poles, P_1 and P_2, cause flux to flow through the rotor **16**. If the rotor is spun on its axis, an electromotive force (E.M.F.) will be generated across the conductors, not shown, under the main field poles. Assuming a squirrel cage rotor, all the conductors are shorted together at either end of the rotor stack, and the voltage generated in the conductors under the influence of the main field flux will cause current to flow. The voltage generated is proportional to the speed of rotation of the rotor **16**, and accordingly, the rotor current is also proportional to speed.

Now, the rotor current causes armature reaction or cross field flux in an axis 90 degrees from the main field

flux associated with the main field poles P_1 and P_2. This cross field flux is also proportional to rotor speed and is picked up by the cross field magnetic circuit P_3 and P_4. Consequently, as the rotor speed increases, the cross field flux through the switch **14** increases, and when the cross field flux has increased to a predetermined value, the switch closes by the leaves **20** and **22** being attracted to each other.

If desired or necessary, the switch **14** can be made to close at any predetermined specific speed by a number of different methods, and in particular by any of the following enumerated means:

(*a*) By adjusting the cross field airgap by shimming the cross field pole P_3 toward or away from the rotor **16**;

(*b*) By adjusting the cross field airgap by moving the pickup shoe P_4 toward or away from the rotor **16**;

(*c*) By shimming the main field pole P_1 and P_2, together or individually toward or away from the rotor **16**, assuming, of course, that the poles are either permanent magnets or else receive a fixed number of ampere turns in field coils;

(*d*) By providing a trimmer winding wound around the main field poles P_1 and P_2 such that flux from this winding will add to or subtract from the main field excitation;

(*e*) If the main field does not have permanent magnets, but is instead of a wound construction, the main field current may be adjusted;

(*f*) By cutting a slot in one of the poles so that the reluctance of the particular pole may be varied by positioning a soft iron wedge within the slot, since the reluctance would depend upon the amount of the slot filled by the wedge.

Generally, adjustment for attainment of a specific predetermined speed may be obtained by changing the main field or cross field airgaps, or changing the main field excitation itself. Also, a change in rotor resistance while maintaining the same number of conductors will change the speed at which the switch **14** operates. If desired, the switch **14** may be made to close at one speed for one direction of rotation of the rotor **16**, and at another speed for the opposite direction of rotation. This may be accomplished by providing a small excitation winding around either the switch **14** or the cross field pole P_3. In this manner, the small flux from this coil will aid armature reaction flux in one direction, and thus permit closure of the switch **14** at a lower speed. It will be obvious that the coil's flux will buck armature reaction for the opposite direction of rotation of the rotor **16** and will thus require a higher speed of rotation for closure of the switch **14**.

Figure 3 illustrates a modification **30** of the preferred embodiment **10**, wherein a number of switches **32** and **34**, similar in principle to the switch **14** of Figure 2, and possibly similar in the specific construction of the integral contact leaves, is utilized in the device of Figure 1. For some particular applications of the subject invention, it may be desirable to have the switches **32** and **34** closed in their normal operative attitude, and opening only when a desired speed is obtained. Accordingly, Figure 3 shows the construction of a main field pole to obtain this specific desirable feature. Hence, in the preferred embodiment **10**, the modification **30** is substituted for one of the main field poles P_1 or P_2, while the switch **14** and the pickup shoe P_4 is replaced by a cross field pole similar in construction and function to P_3.

In the modification **30**, the main field pole is formed with a number of pole tips A' and B' provided with switches **32** and **34**, respectively, biased closed by the main field flux. The switches **32** and **34** are provided with conventional terminals T_1—T_2 and T_3—T_4, respectively. It is generally well known that armature reaction reduces the flux on one side of a main field pole and increases the flux on the other side of the main field pole. Thus, as the speed of the rotor **16** is increased, the armature reaction increases and is picked up by the

cross field poles P_3 and the new pole substituted for the pickup shoe P_4 and the switch **14** in Figure 1. Hence, this speed increase causes the flux in one main pole tip, A' or B' to decrease and finally, when the armature reaction increases sufficiently, the switch in the pole tip being demagnetized will open. It will be obvious, that for the opposite direction of rotation of the rotor **16**, armature reaction will demagnetize the other pole tip causing the switch associated therewith to open. As enumerated above, adjustment of the switches **32** or **34**, individually or together, to operate at a specific predetermined speed may be accomplished by changing the various airgaps between the poles or the field strengths.

It is obviously an inherent feature of the present invention that instead of using the modification **30**, which is somewhat detailed in construction, the same results may be obtained by using a three leave switch for switch **14** in the preferred embodiment of Figure 1. In this manner, a normally closed circuit in lieu of a normally open circuit can be built using a switch of such construction that three parallel leaves are utilized.

The leaves, would comprise two adjacent and parallel magnetic leaves, similar in construction as **20** and **22**, and one non-magnetic leaf adjacent and parallel to one of the magnetic leaves, wherein the non-magnetic leaf and the adjacent magnetic leaf are normally closed, to form the closed circuit, while the adjacent magnetic leaves remain open. In this manner, the circuit through the non-magnetic leaf can be opened whenever the cross magnetic field flux reaches a predetermined amount and causes the two magnetic leaves to attract each other. Hence, the normally closed circuit is predeterminedly opened as a function of speed.

In general, the use of a direct current and, especially, permanent magnetic field is most desirable, however, the device will also perform on alternating current field excitation. Further, the subject invention may be used to produce current limit in an uncompensated motor or generator or any motor or generator where the switch may be placed in the armature reaction flux, since the basic principle of the device gives a switch closure as a function of armature reaction. Also, the present invention may be utilized as a speed regulator wherein the switch, such as switch **14** in the preferred embodiment **10** will close at high speed and open when the speed is reduced, or switches **32** and **34** in the modification **30** wherein the switches open at high speed and close when the speed is reduced.

Briefly, the present invention presents an electromechanical speed limit switch which is much simpler than conventional centrifugal type speed cutouts. Further, the preferred embodiment **10**, with or without the modification **30** has fewer parts than its comparable conventional speed limit switch, and, accordingly, is relatively inexpensive to manufacture. The present device is highly reliable and has no slip rings or aging problem associated therewith and is stable in adjustment, since adjusting screws are not nearly so likely to loosen as on centrifugal devices, for no adjustments are present on rotating parts. Since the switches **14** or **32** and **34**, when properly biased, will operate on a change of flux no larger than the earth's magnetic field, the device is capable of operation at extremely low speeds, and certainly much lower speeds than practical with conventional centrifugal devices. Finally, unlike centrifugal overspeed switches, the present invention is completely unaffected by forces due to gravity, linear acceleration, or other possible unwanted inputs.

It should be understood, of course, that the foregoing disclosure relates to only preferred embodiments of the invention and that it is intended to cover all changes and modifications of the examples of the invention herein chosen for the purposes of the disclosure, which do not constitute departures from the spirit and scope of the

invention as set forth in the appended claims on the following pages.

What is claimed is:

1. A limit switch having a pair of permanent magnetic field poles with a main field flux associated therewith, a soft iron field yoke supporting said poles in diametrically opposite concentric positions, a cross field pole secured to said yoke and located approximately between said main field poles, a switch diametrically opposed from said cross field pole and having a pickup shoe operatively associated therewith, said switch having a number of parallel and resilient leaves predeterminedly responsive to a cross field flux between said cross field pole and said pickup shoe and, in turn, to the main field flux.

2. A limit switch having a number of main field poles, cross field means operatively associated with said main field poles, a soft iron yoke concentrically supported with said field poles, a rotor concentric to said yoke causing an armature reaction in the axis of said cross field means proportional to rotor speed, and switch means operatively coupled to said cross field means and operatively responsive to said armature reaction.

3. An electromechanical limit switch adapted for use with an electrical circuit, comprising a number of permanent magnetic field poles having a main field flux, a field yoke operatively associated with said field poles, cross field pole circumferentially spaced from said magnetic field poles and coupled to said yoke, switch means fixed to said yoke diametrically opposite said cross field pole, pickup means coupled to said switch means, a rotor concentrically mounted relative to said field yoke and operative in said main field flux to produce a cross magnetic field flux, said pickup means cooperating with said cross field pole to direct said cross magnetic field flux to said switch means to control the circuit.

4. An electromechanical limit switch for an electrical circuit, comprising a field yoke, magnetic field poles suitably secured to said yoke, a cross field pole secured to said yoke and circumferentially spaced from said magnetic field pole, a pickup shoe coupled to said yoke diametrically opposite from said cross field pole, a switch secured to said pickup shoe and mounted on said field yoke, a rotor concentrically mounted with respect to said field yoke to generate a cross field flux proportional to rotor speed, said cross field flux directed by said cross field pole and said pickup shoe to said switch to close the electrical circuit at a predetermined rotor speed.

5. The invention as claimed in claim 3 but further characterized by said switch having a pair of parallel magnetic contact leaves magnetically affected by said cross field flux and, in turn, responsive to the rotor speed.

6. An electromechanical limit switch having a yoke member, a number of main field poles diametrically spaced and secured to said yoke member, one of said main field poles having a number of pole tips, switch means associated with each of said pole tips and responsive to a main field flux, a number of cross field poles secured to said yoke member and circumferentially spaced from said main field poles, a rotor member concentric to said yoke member and generating an armature reaction across said cross field poles differentially affecting the magnetic flux across said main pole tips in response to rotor speed to predeterminedly demagnetize and open one of said switch means.

7. A limit switch comprising main field magnetic circuit means including means for producing a main field flux, cross field magnetic circuit means operatively associated with said main field magnetic circuit means, rotor means rotatably supported with respect to both of said magnetic circuit means for producing an armature reaction effective to change the flux associated with both of said magnetic circuit means, and switch means operatively coupled to one of said magnetic circuit means and operatively responsive to said change in flux produced therein by said armature reaction.

8. A limit switch according to claim 7 wherein said main field magnetic circuit means includes a pair of main field poles, said cross field magnetic circuit means includes a pair of cross field poles and one of said field poles has said switch means operatively coupled thereto.

9. A limit switch according to claim 8 wherein one of said cross field poles comprises a pickup shoe operatively coupled to said switch means.

10. A limit switch according to claim 8 wherein one of said main field poles has a pair of pole tips, and said switch means comprises a pair of switches respectively associated with said pole tips.

11. A limit switch according to claim 10 wherein both switches of said pair are biased to a normally closed position by said main field flux and one of said switches of said pair is caused to open by change in the flux due to the armature reaction produced at a predetermined rotor speed.

12. The method of actuating a speed limit switch operable on a small amount of magnetic flux comprising the steps of producing a main field flux, producing an armature reaction in cooperation with said main field flux to create a flux change as a function of speed, and subjecting the switch to said change in flux produced by said armature reaction to provide switch operation as a function of armature reaction and thus as a function of speed.

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