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(54) MOTION DETECTING SYSTEM FOR USE IN A SAFETY SYSTEM FOR POWER EQUIPMENT

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(57) **ABSTRACT**

A woodworking machine including a detection system adapted to detect a dangerous condition between a person and a working portion of the machine is disclosed. The machine includes a reaction system associated with the detection system to cause a predetermined action to take place relative to the working portion upon detection of the dangerous condition. A motion detection system is adapted to detect motion of the working portion and to disable the reaction system when the working portion is not moving. The motion detection system may sense whether motion in a machine has stopped by monitoring the back emf produced on the motor leads as the motor coasts to a stop. The woodworking machine may take the form of a saw, the working portion may be a blade adapted to cut when spinning, and the dangerous condition may be a person contacting the blade.

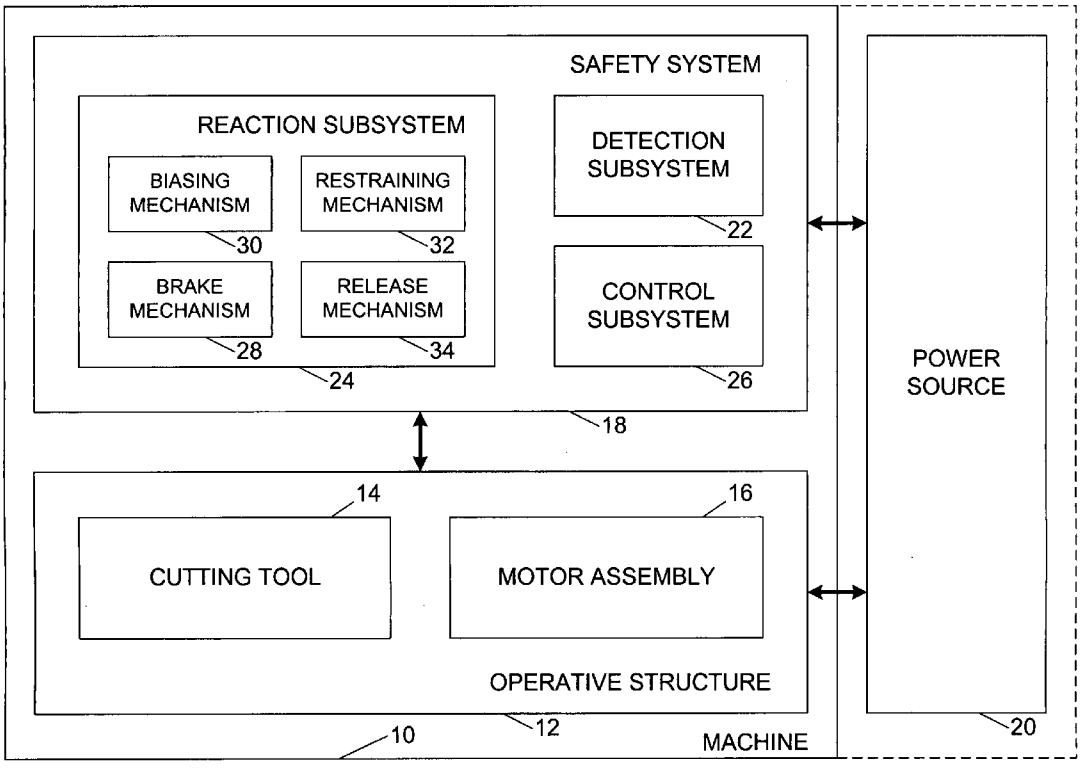
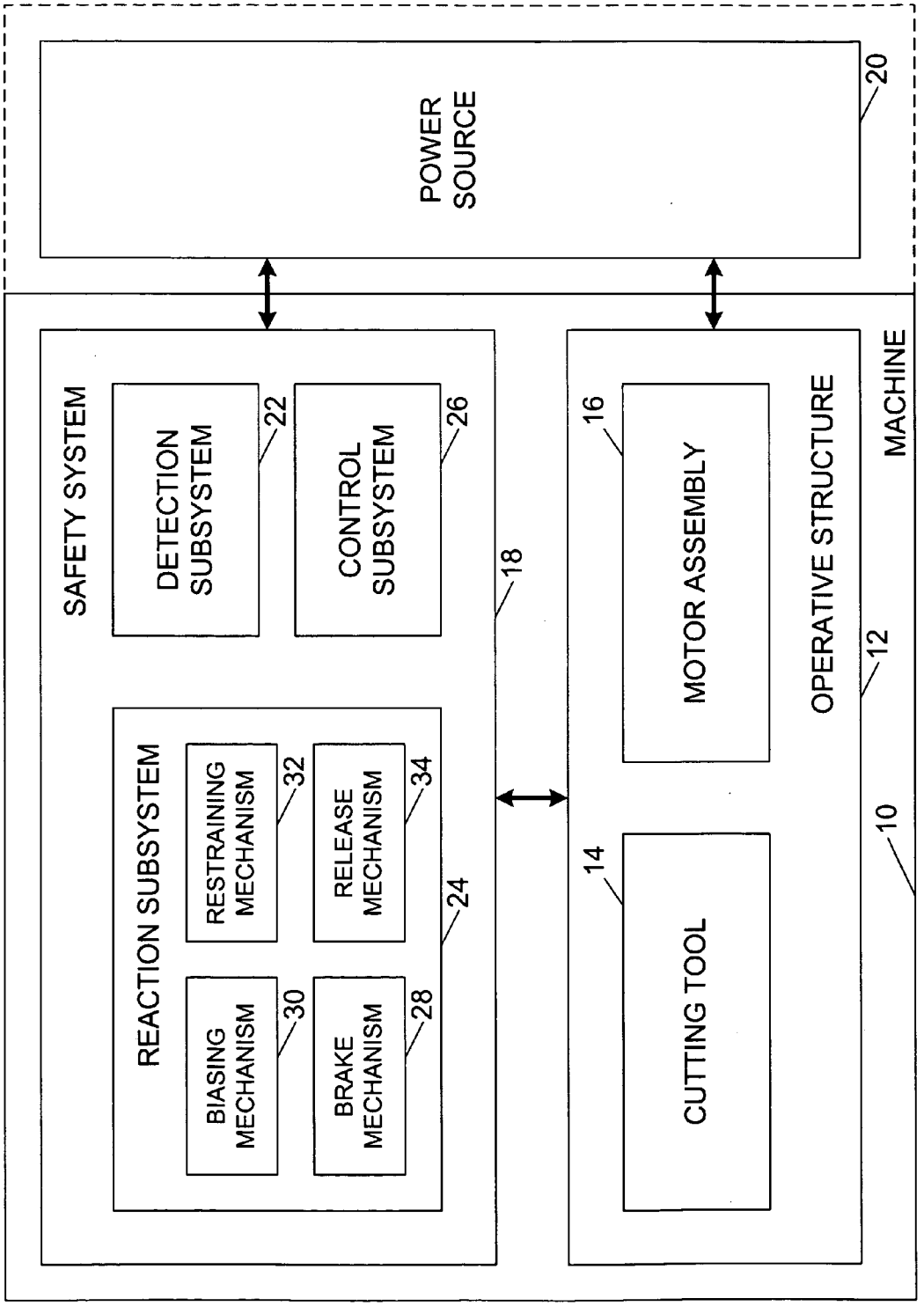


Fig. 1


POWER SOURCE
20
SAFETY SYSTEM
DETECTION SUBSYSTEM
22
CONTROL SUBSYSTEM
26
18
REACTION SUBSYSTEM
RESTRAINING MECHANISM
32
RELEASE MECHANISM
34
BIASING MECHANISM
30
BRAKE MECHANISM
28
24
16
MOTOR ASSEMBLY
OPERATIVE STRUCTURE
12
MACHINE
14
CUTTING TOOL
10

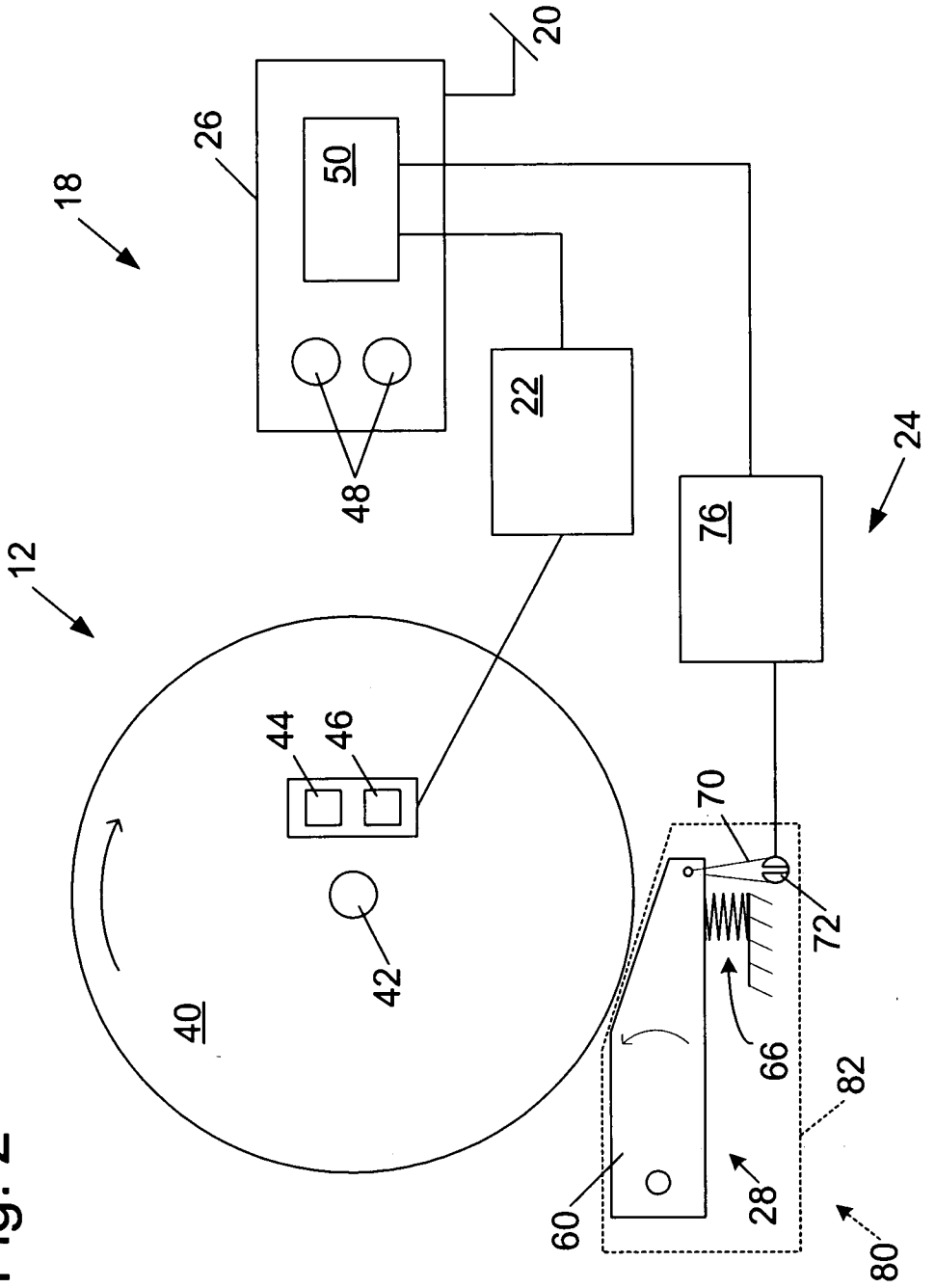


Fig. 2

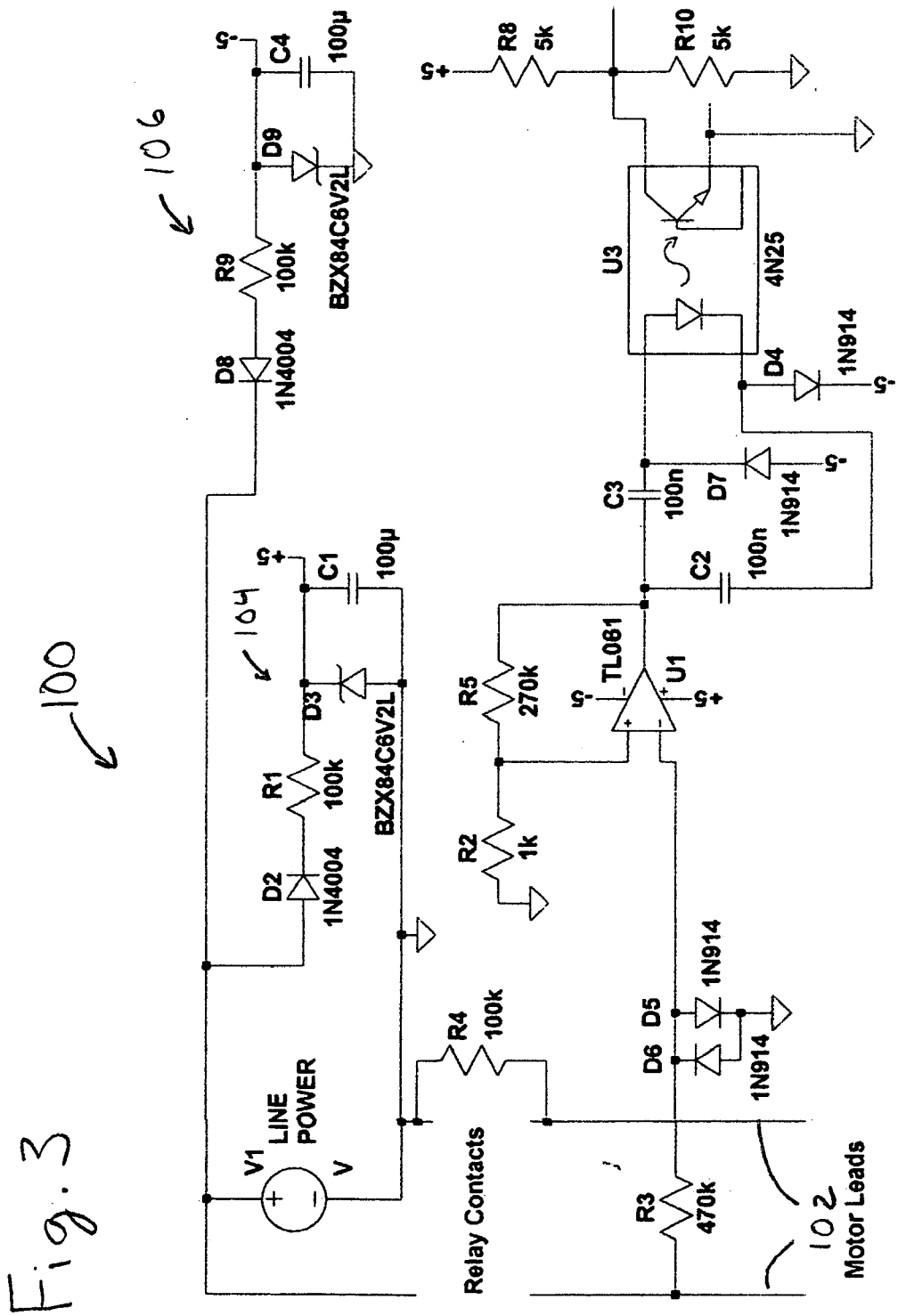

100
106
104
C4 100µ
D9
BZX84C6V2L
R9 100k
D8 1N4004
C1 100µ
D3
BZX84C6V2L
R1 100k
D2 1N4004
V1 LINE POWER
V
R4 100k
Relay Contacts
R8 5k
R10 5k
U3 4N25
D4 1N914
C3 100n
D7 1N914
C2 100n
TL081
U1
R5 270k
R2 1k
D5 1N914
D6 1N914
R3 470k
102
Motor Leads

Fig. 3

MOTION DETECTING SYSTEM FOR USE IN A SAFETY SYSTEM FOR POWER EQUIPMENT

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of and priority from the following U.S. Provisional Patent Application, the disclosure of which is herein incorporated by reference: Serial No. 60/496,568, filed Aug. 20, 2003.

FIELD

[0002] The present invention relates to safety systems for power equipment, and more particularly, to motion detecting systems for use in safety systems for woodworking equipment and other power equipment.

BACKGROUND

[0003] Safety systems are often employed with power equipment such as table saws, miter saws, band saws, jointers, shapers, circular saws and other woodworking machinery, to minimize the risk of injury when using the equipment. Probably the most common safety feature is a guard that physically blocks an operator from making contact with dangerous components of the equipment, such as blades, belts, or shafts. In many cases, guards effectively reduce the risk of injury, however, there are many instances where the nature of the operations to be performed precludes using a guard that completely blocks access to hazardous machine parts.

[0004] Other safety systems try to prevent or minimize injury by detecting and reacting to an event. For instance, U.S. Pat. Nos. 3,953,770, 4,075,961, 4,470,046, 4,532,501 and 5,212,621, the disclosures of which are incorporated herein by reference, disclose radio-frequency safety systems which utilize radio-frequency signals to detect the presence of a user's hand in a dangerous area of a machine and thereupon prevent or interrupt operation of the machine. U.S. Pat. Nos. 3,785,230 and 4,026,177, the disclosures of which are herein incorporated by reference, disclose a safety system for use on circular saws to stop the blade when a user's hand approaches the blade. The system uses the blade as an antenna in an electromagnetic proximity detector to detect the approach of a user's hand prior to actual contact with the blade. Upon detection of a user's hand, the system engages a brake using a standard solenoid.

[0005] U.S. Pat. No. 4,117,752, which is herein incorporated by reference, discloses a braking system for use with a band saw, where the brake is triggered by actual contact between the user's hand and the blade. However, the system described for detecting blade contact does not appear to be functional to accurately and reliably detect contact. Furthermore, the system relies on standard electromagnetic brakes operating off of line voltage to stop the blade and pulleys of the band saw. It is believed that such brakes would take 50 ms–1s to stop the blade. Therefore, the system is too slow to stop the blade quickly enough to avoid serious injury.

[0006] The present document discloses safety systems for use on power equipment. The disclosed safety systems include a replaceable brake cartridge adapted to engage a blade or other cutting tool to protect the user against serious injury if a dangerous, or triggering, condition occurs.

[0007] It is often necessary for an equipment operator to touch the blade or other cutting device of power equipment when the blade or device is not moving (e.g., to adjust the blade, perform equipment maintenance, etc.). Thus, it would be desirable to disable the safety system when the blade is not moving since there is no danger to the user from contact with the blade.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] **FIG. 1** is a schematic block diagram of a machine with a fast-acting safety system.

[0009] **FIG. 2** is a schematic diagram of an exemplary safety system in the context of a machine having a circular blade.

[0010] **FIG. 3** shows an electrical circuit that can be used to determine whether motion in a machine has stopped.

DETAILED DESCRIPTION

[0011] A machine incorporating a safety system is shown schematically in **FIG. 1** and indicated generally at **10**. Machine **10** may be any of a variety of different machines adapted for cutting workpieces, such as wood or plastic, including a table saw, miter saw or chop saw, radial arm saw, circular saw, band saw, jointer, planer, etc. Machine **10** includes an operative structure **12** having a cutting tool **14** and a motor assembly **16** adapted to drive the cutting tool. Machine **10** also includes a safety system **18** configured to minimize the potential of a serious injury to a person using the machine. Safety system **18** is adapted to detect the occurrence of one or more dangerous conditions during use of the machine. If such a dangerous condition is detected, safety system **18** is adapted to engage operative structure **12** to limit any injury to the user caused by the dangerous condition.

[0012] Machine **10** also includes a suitable power source **20** to provide power to operative structure **12** and safety system **18**. Power source **20** may be an external power source such as line current, or an internal power source such as a battery. Alternatively, power source **20** may include a combination of both external and internal power sources. Furthermore, power source **20** may include two or more separate power sources, each adapted to power different portions of machine **10**.

[0013] It will be appreciated that operative structure **12** may take any one of many different forms. For example, operative structure **12** may include a stationary housing configured to support motor assembly **16** in driving engagement with cutting tool **14**. Alternatively, operative structure **12** may include one or more transport mechanisms adapted to convey a work piece toward and/or away from cutting tool **14**.

[0014] Motor assembly **16** includes at least one motor adapted to drive cutting tool **14**. The motor may be either directly or indirectly coupled to the cutting tool, and may also be adapted to drive work piece transport mechanisms. Cutting tool **14** typically includes one or more blades or other suitable cutting implements that are adapted to cut or remove portions from the workpieces. For example, in table saws, miter saws, circular saws and radial arm saws, cutting tool **14** will typically include one or more circular rotating blades having a plurality of teeth disposed along the perimeter of the blade. Alternatively, the cutting tool may be a plurality of circular blades, such as a dado blade or dado

stack. For a jointer or planer, the cutting tool typically includes a plurality of radially spaced-apart blades. For a band saw, the cutting tool includes an elongate, circuitous tooth-edged band.

[0015] Safety system **18** includes a detection subsystem **22**, a reaction subsystem **24** and a control subsystem **26**. Control subsystem **26** may be adapted to receive inputs from a variety of sources including detection subsystem **22**, reaction subsystem **24**, operative structure **12** and motor assembly **16**. The control subsystem may also include one or more sensors adapted to monitor selected parameters of machine **10**. In addition, control subsystem **26** typically includes one or more instruments operable by a user to control the machine. The control subsystem is configured to control machine **10** in response to the inputs it receives.

[0016] Detection subsystem **22** is configured to detect one or more dangerous, or triggering, conditions during use of machine **10**. For example, the detection subsystem may be configured to detect that a portion of the user's body is dangerously close to, or in contact with, a portion of cutting tool **14**. As another example, the detection subsystem may be configured to detect the rapid movement of a workpiece due to kickback by the cutting tool, as is described in U.S. patent application Ser. No. 09/676,190, the disclosure of which is herein incorporated by reference. In some embodiments, detection subsystem **22** may inform control subsystem **26** of the dangerous condition, which then activates reaction subsystem **24**. In other embodiments, the detection subsystem may be adapted to activate the reaction subsystem directly.

[0017] Once activated in response to a dangerous condition, reaction subsystem **24** is configured to engage operative structure **12** quickly to prevent serious injury to the user. It will be appreciated that the particular action to be taken by reaction subsystem **24** will vary depending on the type of machine **10** and/or the dangerous condition that is detected. For example, reaction subsystem **24** may be configured to do one or more of the following: stop the movement of cutting tool **14**, disconnect motor assembly **16** from power source **20**, place a barrier between the cutting tool and the user, or retract the cutting tool from its operating position, etc. The reaction subsystem may be configured to take a combination of steps to protect the user from serious injury. Placement of a barrier between the cutting tool and teeth is described in more detail in U.S. Patent Application Publication No. 2002/0017183 A1, entitled "Cutting Tool Safety System," the disclosure of which is herein incorporated by reference. Retracting the cutting tool is described in more detail in U.S. Patent Application Publication No. 2002/0017181 A1, entitled "Retraction System for Use in Power Equipment," and U.S. Patent Application Ser. No. 60/452,159, filed Mar. 5, 2003, entitled "Retraction System and Motor Position for Use With Safety Systems for Power Equipment," the disclosures of which are herein incorporated by reference.

[0018] The configuration of reaction subsystem **24** typically will vary depending on which action(s) are taken. In the exemplary embodiment depicted in **FIG. 1**, reaction subsystem **24** is configured to stop the movement of cutting tool **14** and includes a brake mechanism **28**, a biasing mechanism **30**, a restraining mechanism **32**, and a release mechanism **34**. Brake mechanism **28** is adapted to engage operative structure **12** under the urging of biasing mechanism **30**. During normal operation of machine **10**, restraining mechanism **32** holds the brake mechanism out of engagement with the operative structure. However, upon receipt of an activation signal by reaction subsystem **24**, the brake mechanism is released from the restraining mechanism by release mechanism **34**, whereupon, the brake mechanism quickly engages at least a portion of the operative structure to bring the cutting tool to a stop.

[0019] It will be appreciated by those of skill in the art that the exemplary embodiment depicted in **FIG. 1** and described above may be implemented in a variety of ways depending on the type and configuration of operative structure **12**. Turning attention to **FIG. 2**, one example of the many possible implementations of safety system **18** is shown. System **18** is configured to engage an operative structure having a circular blade **40** mounted on a rotating shaft or arbor **42**. Blade **40** includes a plurality of cutting teeth (not shown) disposed around the outer edge of the blade. As described in more detail below, braking mechanism **28** is adapted to engage the teeth of blade **40** and stop the rotation of the blade. U.S. Patent Application Publication No. 2002/0017175 A1, entitled "Translation Stop For Use In Power Equipment," the disclosure of which is herein incorporated by reference, describes other systems for stopping the movement of the cutting tool. U.S. Patent Application Publication No. 2002/0017184 A1, entitled "Table Saw With Improved Safety System," U.S. Patent Application Publication No. 2002/0017179 A1, entitled "Miter Saw With Improved Safety System," U.S. Patent Application Publication No. 2002/0059855 A1, entitled "Miter Saw with Improved Safety System," U.S. Patent Application Publication No. 2002/0056350 A1, entitled "Table Saw With Improved Safety System," U.S. Patent Application Publication No. 2002/0059854 A1, entitled "Miter Saw With Improved Safety System," U.S. Patent Application Publication No. 2002/0056349 A1, entitled "Miter Saw With Improved Safety System," U.S. Patent Application Publication No. 2002/0056348 A1, entitled "Miter Saw With Improved Safety System," and U.S. Patent Application Publication No. 2002/0066346 A1, entitled "Miter Saw With Improved Safety System," U.S. Patent Application Publication No. 2003/0015253 A1, entitled "Router With Improved Safety System," U.S. Patent Application Publication No. 2002/0170400 A1, entitled "Band Saw With Improved Safety System," U.S. Patent Application Publication No. 2003/0019341 A1, entitled "Safety Systems for Band Saws," U.S. Patent Application Publication No. 2003/0056853 A1, entitled "Router With Improved Safety System," U.S. Provisional Patent Application Ser. No. 60/406,138, entitled "Miter Saw With Improved Safety System," filed Aug. 27, 2002 by SD3, LLC, and U.S. Provisional Patent Application Ser. No. 60/496,550, entitled "Table Saws with Safety Systems and Blade Retraction," filed Aug. 20, 2003 by SD3, LLC, the disclosures of which are all herein incorporated by reference, describe safety system **18** in the context of particular types of machines.

[0020] In the exemplary implementation, detection subsystem **22** is adapted to detect the dangerous condition of the user coming into contact with blade **40**. The detection subsystem includes a sensor assembly, such as contact detection plates **44** and **46**, capacitively coupled to blade **40** to detect any contact between the user's body and the blade. Typically, the blade, or some larger portion of cutting tool **14** is electrically isolated from the remainder of machine **10**.

Alternatively, detection subsystem **22** may include a different sensor assembly configured to detect contact in other ways, such as optically, resistively, etc. In any event, the detection subsystem is adapted to transmit a signal to control subsystem **26** when contact between the user and the blade is detected. Various exemplary embodiments and implementations of detection subsystem **22** are described in more detail in U.S. Patent Application Publication No. 2002/0017176 A1, entitled "Detection System For Power Equipment," U.S. Patent Application Publication No. 2002/0017336 A1, entitled "Apparatus And Method For Detecting Dangerous Conditions In Power Equipment," U.S. Patent Application Publication No. 2002/0069734 A1, entitled "Contact Detection System for Power Equipment," U.S. Patent Application Publication No. 2002/0190581 A1, entitled "Apparatus and Method for Detecting Dangerous Conditions in Power Equipment," U.S. Patent Application Publication No. 2003/0002942 A1, entitled "Discrete Proximity Detection System," and U.S. Patent Application Publication No. 2003/0090224 A1, entitled "Detection System for Power Equipment," the disclosures of which are herein incorporated by reference.

[**0021**] Control subsystem **26** includes one or more instruments **48** that are operable by a user to control the motion of blade **40**. Instruments **48** may include start/stop switches, speed controls, direction controls, etc. Control subsystem **26** also includes a logic controller **50** connected to receive the user's inputs via instruments **48**. Logic controller **50** is also connected to receive a contact detection signal from detection subsystem **22**. Further, the logic controller may be configured to receive inputs from other sources (not shown) such as blade motion sensors, work piece sensors, etc. In any event, the logic controller is configured to control operative structure **12** in response to the user's inputs through instruments **48**. However, upon receipt of a contact detection signal from detection subsystem **22**, the logic controller overrides the control inputs from the user and activates reaction subsystem **24** to stop the motion of the blade. Various exemplary embodiments and implementations of control subsystem **26** are described in more detail in U.S. Patent Application Publication No. 2002/0020262 A1, entitled "Logic Control For Fast Acting Safety System," U.S. Patent Application Publication No. 2002/0017178 A1, entitled "Motion Detecting System For Use In Safety System For Power Equipment," and U.S. Patent Application Publication No. 2003/0058121 A1, entitled "Logic Control With Test Mode for Fast-Acting Safety System," the disclosures of which are herein incorporated by reference.

[**0022**] In the exemplary implementation, brake mechanism **28** includes a pawl **60** mounted adjacent the edge of blade **40** and selectively moveable to engage and grip the teeth of the blade. Pawl **60** may be constructed of any suitable material adapted to engage and stop the blade. As one example, the pawl may be constructed of a relatively high strength thermoplastic material such as polycarbonate, ultrahigh molecular weight polyethylene (UHMW) or Acrylonitrile Butadiene Styrene (ABS), etc., or a metal such as aluminum, etc. It will be appreciated that the construction of pawl **60** may vary depending on the configuration of blade **40**. In any event, the pawl is urged into the blade by a biasing mechanism in the form of a spring **66**. In the illustrative embodiment shown in **FIG. 2**, pawl **60** is pivoted into the teeth of blade **40**. It should be understood that sliding or rotary movement of pawl **60** might also be used. The spring is adapted to urge pawl **60** into the teeth of the blade with sufficient force to grip the blade and quickly bring it to a stop.

[**0023**] The pawl is held away from the edge of the blade by a restraining mechanism in the form of a fusible member **70**. The fusible member is constructed of a suitable material adapted to restrain the pawl against the bias of spring **66**, and also adapted to melt under a determined electrical current density. Examples of suitable materials for fusible member **70** include NiChrome wire, stainless steel wire, etc. The fusible member is connected between the pawl and a contact mount **72**. Preferably, fusible member **70** holds the pawl relatively close to the edge of the blade to reduce the distance the pawl must travel to engage the blade. Positioning the pawl relatively close to the edge of the blade reduces the time required for the pawl to engage and stop the blade. Typically, the pawl is held approximately 1/32-inch to 1/4-inch from the edge of the blade by fusible member **70**; however other pawl-to-blade spacings may also be used within the scope of the invention.

[**0024**] Pawl **60** is released from its unactuated, or cocked, position to engage blade **40** by a release mechanism in the form of a firing subsystem **76**. The firing subsystem is coupled to contact mount **72**, and is configured to melt fusible member **70** by passing a surge of electrical current through the fusible member. Firing subsystem **76** is coupled to logic controller **50** and activated by a signal from the logic controller. When the logic controller receives a contact detection signal from detection subsystem **22**, the logic controller sends an activation signal to firing subsystem **76**, which melts fusible member **70**, thereby releasing the pawl to stop the blade. Various exemplary embodiments and implementations of reaction subsystem **24** are described in more detail in U.S. Patent Application Publication No. 2002/0020263 A1, entitled "Firing Subsystem For Use In A Fast-Acting Safety System," U.S. Patent Application Publication No. 2002/0020271 A1, entitled "Spring-Biased Brake Mechanism for Power Equipment," U.S. Patent Application Publication No. 2002/0017180 A1, entitled "Brake Mechanism For Power Equipment," U.S. Patent Application Publication No. 2002/0059853 A1, entitled "Power Saw With Improved Safety System," U.S. Patent Application Publication No. 2002/0020265 A1, entitled "Translation Stop For Use In Power Equipment," U.S. Patent Application Publication No. 2003/0005588 A1, entitled "Actuators For Use in Fast-Acting Safety Systems," and U.S. Patent Application Publication No. 2003/0020336 A1, entitled "Actuators For Use In Fast-Acting Safety Systems," the disclosures of which are herein incorporated by reference.

[**0025**] It will be appreciated that activation of the brake mechanism will require the replacement of one or more portions of safety system **18**. For example, pawl **60** and fusible member **70** typically must be replaced before the safety system is ready to be used again. Thus, it may be desirable to construct one or more portions of safety system **18** in a cartridge that can be easily replaced. For example, in the exemplary implementation depicted in **FIG. 2**, safety system **18** includes a replaceable cartridge **80** having a housing **82**. Pawl **60**, spring **66**, fusible member **70** and contact mount **72** are all mounted within housing **82**. Alternatively, other portions of safety system **18** may be mounted within the housing. In any event, after the reaction system

has been activated, the safety system can be reset by replacing cartridge **80**. The portions of safety system **18** not mounted within the cartridge may be replaced separately or reused as appropriate. Various exemplary embodiments and implementations of a safety system using a replaceable cartridge, and various brake pawls, are described in more detail in U.S. Patent Application Publication No. 2002/0020261 A1, entitled "Replaceable Brake Mechanism For Power Equipment," U.S. Patent Application Publication No. 2002/0017182 A1, entitled "Brake Positioning System," U.S. Patent Application Publication No. 2003/0140749 A1, entitled "Brake Pawls for Power Equipment," and U.S. Provisional Patent Application Ser. No. **60/496,574**, entitled "Brake Cartridges for Power Equipment," filed Aug. 20, 2003 by SD3, LLC, the disclosures of which are herein incorporated by reference.

[**0026**] While one particular implementation of safety system **18** has been described, it will be appreciated that many variations and modifications are possible within the scope of the invention. Many such variations and modifications are described in U.S. Patent Application Publication No. 2002/0170399 A1, entitled "Safety Systems for Power Equipment," U.S. Patent Application Publication No. 2003/0037651, entitled "Safety Systems for Power Equipment," and U.S. Patent Application Publication No. 2003/0131703 A1, entitled "Apparatus and Method for Detecting Dangerous Conditions in Power Equipment," the disclosures of which are herein incorporated by reference.

[**0027**] In the machines and systems described above, it is often desirable to be able to determine if a blade or other dangerous part of a machine has stopped rotation. This information can be used to disable the detection and/or reaction subsystems once the danger has passed.

[**0028**] **FIG. 3** shows an electrical circuit **100** that can be used to determine whether motion in a machine has stopped by monitoring the back emf (electromagnetic field) produced on the motor leads as the motor coasts to a stop. In particular, motor leads **102** connect to a motor (not shown). When the motor is coasting down after power has been removed from the motor, the motor armature will retain a residual magnetic polarization, which will induce an oscillating emf in the motor windings and in the motor leads connected to the windings. This is true for both single and three phase motors. The voltage of the back emf will change sign each **180** degrees of rotation of the armature. Circuit **100** generates a pulse every time the sign of voltage on the motor leads changes as described below. This pulse can be used by a microcontroller or other supervisory circuitry (not shown) to determine when the motor has stopped rotating, and by inference when motion in the machine has ceased.

[**0029**] Circuit **100** includes positive and negative power supplies **104**, **106**, respectively. The supplies are not isolated from the line voltage. The output amplitude of each supply is about 5-6 volts, as determined by the voltage on Zener diodes D3/D9. Capacitors C1/C4 serve to smooth the voltage output during low points in the line voltage.

[**0030**] The negative input of an op-amp U1 is connected to one of the motor leads **102** through resistor R3. Diodes D5 and D6 clip the voltage passing through R3 to plus or minus one diode drop (about 0.6V) of circuit ground—which is just one of the two power lines. The second motor lead is tied to ground through resistor R4, even when the relay contacts or other switching device controlling power to the motor is open. The positive input of op-amp U1 is tied to ground through resistor R2. This maintains the positive input at close to ground, as shifted slightly by feedback resistor R5. When the output of the op-amp is high, the feedback resistor will pull the positive input slightly higher than ground as determined by the resistance ratio of R5/R2. Similarly, when the output of the op-amp is low, the feedback resistor pulls the positive input to slightly less than ground. This arrangement provides an amount of hysteresis on the voltage level at which the negative input will cause the output to change signs. This hysteresis is useful to prevent the output of the op-amp from oscillating when the negative input nears the transition. It also reduces the sensitivity of the zero-cross detection to noise on the motor leads.

[**0031**] As a result of the above described arrangement, each time the back emf on the motor leads changes sign by more than the hysteresis voltage—typically 10-100 mV—the output of the op-amp will change state. The arrangement of capacitors C3, C2, diodes D9 and D4 and optocoupler U3 causes a pulse of current to flow through the LED in optocoupler U3. The pulse of current in turn generates a pulse on the output transistor of optocoupler U3, which pulls down the voltage at the node between resistors R8 and R10. These brief pulses form the output of the above describe zero cross detection circuit that would typically be fed to some type of supervisory circuit.

[**0032**] When power to the motor is first disconnected, the motor is rotating at essentially full speed so that the pulses emanating from the R8/R10 output are occurring at a rate equal to twice the nominal rotation rate of the motor. As the motor coasts down, the back emf voltage decays in amplitude and frequency and the corresponding pulses at R8/R10 decrease in frequency, although the amplitude and duration of each pulse remains constant. At some point the speed of rotation reaches a low enough rate that the back emf is no longer enough to overcome the hysteresis. This typically happens at a rotation rate of around 0.2 to 5 rotations per second. Generally when the motor reaches this speed, it will not complete more than one or two more rotations. If desired, a delay period may be incorporated in the supervisory circuit to wait a predetermined interval after no more pulses are seen to deactivate the detection and or reaction systems.

[**0033**] The circuit described above and shown in **FIG. 3** may be used to detect the motion of a blade or other dangerous part of a machine. Additional information concerning motion-detecting systems is disclosed in U.S. Patent Application Publication No. U.S. 2002/0017178 A1, entitled "Motion Detecting System for Use in a Safety System for Power Equipment," identified above and incorporated herein by reference.

INDUSTRIAL APPLICABILITY

[**0034**] The systems, components and circuits disclosed herein are applicable to power equipment, and specifically to woodworking equipment such as saws.

[**0035**] It is believed that the disclosure set forth above encompasses multiple distinct inventions with independent utility. While each of these inventions has been disclosed in its preferred form, the specific embodiments thereof as disclosed and illustrated herein are not to be considered in a

limiting sense as numerous variations are possible. The subject matter of the inventions includes all novel and non-obvious combinations and sub-combinations of the various elements, features, functions and/or properties disclosed herein. No single feature, function, element or property of the disclosed embodiments is essential to all of the disclosed inventions. Similarly, where the claims recite "a" or "a first" element or the equivalent thereof, such claims should be understood to include incorporation of one or more such elements, neither requiring nor excluding two or more such elements.

[0036] It is believed that the following claims particularly point out certain combinations and sub-combinations that are directed to one of the disclosed inventions and are novel and non-obvious. Inventions embodied in other combinations and sub-combinations of features, functions, elements and/or properties may be claimed through amendment of the present claims or presentation of new claims in this or a related application. Such amended or new claims, whether they are directed to a different invention or directed to the same invention, whether different, broader, narrower or equal in scope to the original claims, are also regarded as included within the subject matter of the inventions of the present disclosure.

1. A woodworking machine comprising:

a cutter;

a motor adapted to drive the cutter;

a detection system adapted to detect a dangerous condition between a user and the cutter;

a reaction system adapted to perform a specified action to mitigate the dangerous condition upon detection of the dangerous condition by the detection system; and

a control system adapted to detect back emf produced by the motor as the motor coasts down after power has been removed from the motor, and further adapted to trigger the reaction system to perform the specified action during coast down of the motor only if back emf is detected.

2. The woodworking machine of claim 1, where the motor has leads and where the control system is connected to the leads.

3. The woodworking machine of claim 1, where the control system is adapted to employ zero-cross detection to detect back emf.

4. The woodworking machine of claim 1, where the control system includes circuitry to detect zero crossings of back emf.

5. The woodworking machine of claim 1, where the control system includes circuitry to detect when the back emf from the motor changes signs.

6. The woodworking machine of claim 5, where the control system is adapted to detect when the back emf from the motor changes signs by at least 10 mV.

7. The woodworking machine of claim 5, where the control system is adapted to detect when the back emf from the motor changes signs by at least 100 mV.

8. The woodworking machine of claim 5, where the control system is adapted to detect when the back emf from the motor changes signs by 10-100 mV.

9. A woodworking machine comprising:

a cutter;

a motor adapted to drive the cutter;

a detection system adapted to detect a dangerous condition between a user and the cutter;

a reaction system adapted to perform a specified action to mitigate the dangerous condition upon detection of the dangerous condition by the detection system; and

a control system adapted to determine whether the cutter is moving by detecting back emf produced by the motor as the motor coasts down after power has been removed from the motor, and further adapted to deactivate the detection and/or reaction system if the cutter is not moving.

10. The woodworking machine of claim 9, where the control system includes circuitry to detect back emf.

11. The woodworking machine of claim 10, where the circuitry is configured to detect zero crossings of back emf.

12. The woodworking machine of claim 10, where the circuitry provides an amount of hysteresis.

13. The woodworking machine of claim 12, where the control system determines the cutter is not moving when the back emf is insufficient to overcome the hysteresis.

14. The woodworking machine of claim 9, where the cutter is a circular blade and where the control system is adapted to determine that the cutter is not moving when the cutter has coasted down to a rate of around 0.2 to 5 rotations per minute.

15. The woodworking machine of claim 9, where a delay period is incorporated into the control system to cause the control system to wait a predetermined interval after no more back emf is detected to deactivate the detection and/or reaction systems.

16. A woodworking machine comprising:

a cutter;

a motor adapted to drive the cutter;

a detection system adapted to detect a dangerous condition between a user and the cutter;

a reaction system adapted to perform a specified action to mitigate the dangerous condition upon detection of the dangerous condition by the detection system; and

control means for detecting back emf produced by the motor as the motor coasts down after power has been removed from the motor, and for triggering the reaction system only if a dangerous condition is detected when a predetermined level of back emf is also detected.

17. The woodworking machine of claim 16, where the machine is a table saw.

18. The woodworking machine of claim 16, where the cutter is a circular blade.

19. The woodworking machine of claim 16, where the control means includes circuit means for detecting zero crossings of back emf.

20. The woodworking machine of claim 16, where the control means includes circuit means for detecting sign changes of back emf.

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