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TITLE

Logic control for fast-acting safety system

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Assistant Commissioner for Patents
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Washington, D.C. 20231

Sir:

Transmitted herewith for filing is a PROVISIONAL patent application of SD3, LLC.

For: **LOGIC CONTROL FOR FAST-ACTING SAFETY SYSTEM**

Also enclosed are:

_X_ Eleven (11) sheets of drawings.

_X_ Appendix A.

_X_ A check in the amount of $75.00 is enclosed for payment of the filing fee.

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PROVISIONAL APPLICATION
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Basic Filing Fee $75.00

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I hereby certify that the attached documents are being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 C.F.R. § 1.10 on the date indicated above and is addressed to: Assistant Commissioner for Patents, Box PROVISIONAL PATENT APPLICATION, Washington, D.C. 20231.

Renee Knight

LOGIC CONTROL FOR FAST-ACTING SAFETY SYSTEM

Field of the Invention

The present invention relates to safety systems, and more particularly to a high-speed safety system for use on power equipment.

Background of the Invention

Beginning with the industrial revolution and continuing to the present, mechanized equipment has allowed workers to produce goods with greater speed and less effort than possible with manually-powered tools. Unfortunately, the power and high operating speeds of mechanized equipment creates a risk for those operating such machinery. Each year thousands of people are maimed or killed by accidents involving power equipment.

As might be expected, many systems have been developed to minimize the risk of injury when using power equipment. Probably the most common safety feature is a guard that physically blocks an operator from making contact with dangerous components of machinery, such as belts, shafts or blades. In many cases, guards are effective to 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.

Various systems have been proposed to prevent accidental injury where guards cannot effectively be employed. For instance, U.S. Patent Nos. 941,726, 2,978,084, 3,011,610, 3,047,116, 4,195,722 and 4,321,841, the disclosures of which are incorporated herein by reference, all disclose safety systems for use with power presses. These systems utilize cables attached to the wrists of the operator that either pull back a user's hands from the work zone upon operation or prevent operation until the user's hands are outside the danger zone. U.S. Patent 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 the machine and thereupon prevent or interrupt operation of the machine.

U.S. Patent Nos. 4,959,909, 5,025,175, 5,122,091, 5,198,702, 5,201,684, 5,272,946, and 5,510,685 disclose safety systems for use with meat-skinning equipment, and are incorporated herein by reference. These systems interrupt or reverse power to the motor, or disengage a clutch, upon contact with a user's hand by any dangerous portion of the machine. Typically, contact between the user and the machine is detected by monitoring for electrical contact between a fine wire mesh in a glove worn by the user and some metal component in the dangerous area of the machine. Although such systems are suitable for use with meat skinning machines, they are relatively slow to stop the motion of the cutting element because they rely on the operation of solenoids or must overcome the inertia of the motor. However, because these systems operate at relatively low speeds, the blade does not need to be stopped rapidly to prevent serious injury to the user.

U.S. Patent 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. Unfortunately, such a system is prone to false triggers and is relatively slow acting because of the solenoid. U.S. Patent No. 4,117,752, which is herein incorporated by reference, discloses a similar 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 50ms-1s to stop the blade. Therefore, the system is too slow to stop the blade quickly enough to avoid serious injury.

None of the safety systems mentioned above disclose any method or mechanism for ensuring that the system is operational before setting the blade or other dangerous portion of the machine in motion. In addition, none of the systems mentioned above disclose any method or mechanism for preventing false triggers during initial startup or monitoring the operating status of the machinery to prevent triggering the safety system when the blade is stationary. Further, none of the above-mentioned systems disclose any method or mechanism for allowing a user to disable the safety system under certain conditions.

Brief Description of the Drawings

Fig. 1 is a schematic block diagram of a machine with a fast-acting safety system according to the present invention.

Fig. 2 is a schematic diagram of an exemplary safety system in the context of a machine having a circular blade.

Fig. 3 is a flowchart diagram of an exemplary self-test logic sequence according to the present invention.

Figs. 4A-C are flowchart diagrams of an exemplary self-test and operational sequence according to the present invention.

Fig. 5 is a schematic block diagram of a logic controller according to a first exemplary implementation of the present invention.

Fig. 6 is a schematic diagram of a user interface according to the present invention.

Fig. 7 is a schematic diagram of a firing capacitor charge and test circuit according to the first exemplary implementation of the present invention.

Fig. 8 is a schematic block diagram of a logic controller according to a second exemplary implementation of the present invention.

Fig. 9 is a schematic diagram of a firing capacitor charge and test circuit according to the second exemplary implementation of the present invention.

Fig. 10 is an isometric view of an exemplary pawl adapted for measuring pawl-to-blade spacing according to the present invention.

Fig. 11 is a schematic diagram of an exemplary circuit for detecting blade-to-pawl spacing according to the present invention.

Exhibits

Exhibit A are exemplary software instructions and functional flowcharts suitable for use with the PIC16C63A-20/SO controller.

Detailed Description and Best Mode of the Invention

A machine according to the present invention 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, including a table saw, miter saw (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 machine 10. Safety system 18 is adapted to detect the occurrence of one or more dangerous conditions during use of machine 10. 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.

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.

It will be appreciated that operative structure 12 may take any one of many different forms, depending on the type of machine 10. 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 a movable structure configured to carry cutting tool 14 between multiple operating positions. As a further alternative, operative structure 12 may include one or more transport mechanisms adapted to convey a workpiece toward and/or away from cutting tool 14.

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Motor assembly 16 includes one or more motors adapted to drive cutting tool 14. The motors may be either directly or indirectly coupled to the cutting tool, and may also be adapted to drive workpiece 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. The particular form of cutting tool 14 will vary depending upon the various embodiments of machine 10. 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 perimetrical edge of the blade. 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.

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.

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. Provisional Patent Application Serial No. 60/182,866, 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.

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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. Provisional Patent Application Serial No. _________, entitled "Cutting Tool Safety System," filed August 14, 2000 by SD3, LLC, the disclosure of which is herein incorporated by reference. Retraction of the cutting tool from its operating position is described in more detail in U.S. Provisional Patent Application Serial No. _________, entitled "Retraction System For Use In Power Equipment," filed August 14, 2000 by SD3, LLC, the disclosure of which is herein incorporated by reference.

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.

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

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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 cutting tool in the form of 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. Provisional Patent Application Serial No. _________, entitled "Translation Stop For Use In Power Equipment," filed August 14, 2000 by SD3, LLC, the disclosure of which is herein incorporated by reference, describes other systems for stopping the movement of the cutting tool. U.S. Provisional Patent Application Serial No. _________, entitled "Table Saw With Improved Safety System," filed August 14, 2000 by SD3, LLC, and U.S. Provisional Patent Application Serial No. _________, entitled "Miter Saw With Improved Safety System," filed August 14, 2000 by SD3, LLC, the disclosures of which are herein incorporated by reference, describe safety system 18 in the context of particular types of machines 10.

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. Provisional Patent Application Serial No. _________, entitled "Contact Detection System For Power Equipment," filed August 14, 2000 by SD3, LLC, and U.S. Provisional Patent Application Serial No. _________, entitled "Apparatus And Method For Detecting Dangerous Conditions In Power Equipment," filed August 14, 2000 by SD3, LLC, the disclosures of which are herein incorporated by reference.

Control subsystem 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, workpiece 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 logic controller 50 will be described below. Various exemplary embodiments and implementations of a blade motion detection system are described in U.S. Provisional Patent Application Serial No. _________, entitled "Motion Detecting System For Use In Safety System For Power Equipment," filed August 14, 2000 by SD3, LLC, the disclosure of which is herein incorporated by reference.

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 will 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 may also be used. The spring is adapted to urge pawl 60

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into the teeth of the blade with sufficient force to grip the blade and quickly bring it to a stop.

The pawl is held away from the edge of the blade by a restraining member 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 member 70 holds the pawl relatively close to the edge of the blade to reduce the distance pawl 60 must travel to engage blade 40. 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 ¼-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.

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. Provisional Patent Application Serial No. _________, entitled "Firing Subsystem For Use In Fast Acting Safety System," filed August 14, 2000 by SD3, LLC, U.S. Provisional Patent Application Serial No. _________, entitled "Spring-Biased Brake Mechanism for Power Equipment," filed August 14, 2000 by SD3, LLC, and U.S. Provisional Patent Application Serial No. _________, entitled "Brake Mechanism For Power Equipment," filed August 14, 2000 by SD3, LLC, the disclosures of which are herein incorporated by reference.

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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 are described in more detail in U.S. Provisional Patent Application Serial No. _________, entitled "Replaceable Brake Mechanism For Power Equipment," filed August 14, 2000 by SD3, LLC, and U.S. Provisional Patent Application Serial No. _________, entitled "Brake Positioning System," filed August 14, 2000 by SD3, LLC, the disclosures of which are herein incorporated by reference.

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. Provisional Patent Application Serial Nos. 60/182,866 and 60/157,340, the disclosures of which are herein incorporated by reference.

Considering logic controller 50 now in more detail, it will be appreciated that the logic controller may be configured to perform a variety of functions depending on the particular type of machine 10 and/or the application. For example, logic controller 50 may be configured to conduct various self-test safety checks when the machine is switched on or off and during use, to ensure that detection subsystem 22 is operating

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properly and to prevent inadvertent triggering of reaction subsystem 24. Additionally, the logic controller may be configured to control one or more display devices to inform a user of the status of machine 10 and safety system 18. Furthermore, logic controller 50 may be implemented in a variety of ways including using one or more custom application specific integrated circuits (ASICs), microprocessors, micro-controllers, digital logic circuits, and/or analog circuits, etc.

In one exemplary embodiment, logic controller 50 is configured to perform the self-check logic sequence shown in Fig. 3. The exemplary sequence begins when the user initially supplies power to the system, indicated at 901. The logic system first checks to determine whether the spacing between the blade and pawl is correct, as indicated at 902. The blade-to-pawl spacing may be measured by any suitable mechanism such as described in more detail below. If the spacing is outside acceptable limits, the system responds with an error signal, indicated at 903. The error signal may be an audible and/or visible signal, etc. In one embodiment described in more detail below, control subsystem includes a user interface adapted to indicate the status of the machine and annunciate any error conditions. Preferably, the logic system remains in the error state and prevents further operation of the machine until the correct blade-to-pawl spacing is detected.

If the blade-to-pawl spacing is acceptable, the logic system determines whether the input signal produced on charge plate 44 by detection subsystem 22 is being detected at a sufficient amplitude on charge plate 46, as indicated at 904. This step ensures that the reaction subsystem will not be triggered accidentally upon start-up due to a fault in the detection subsystem, a grounded blade, incorrectly placed charge plates, etc. If the proper input signal is not detected, logic controller 50 responds with an error signal 903. It will be appreciated that either the same or a different error signal may be produced for each fault condition.

If the proper input signal is detected, the logic controller proceeds to determine whether a fusible member is present, as indicated at step 905. The presence of a fusible member may be determined by any suitable means such as described in more detail below. If no fusible member is present, logic controller 50 returns an error signal 903. If a fusible member is detected, the logic controller then checks the electrical charge stored by firing subsystem 76, as indicated at 906. This step ensures that sufficient charge is present to melt the fusible member if the dangerous condition is detected. Exemplary circuitry for detecting sufficient charge is described in more detail below. If sufficient charge is not detected within a determined time period, the logic controller responds with an error signal 903.

In the sequence depicted in Fig. 3, after the predetermined checks are completed, logic controller 50 allows power to be sent to motor assembly 16, as indicated at 907. It will be appreciated that the electrical sequence described above typically is completed within no more than a few seconds if no faults are detected. In addition to an initial power-up sequence, logic controller 50 may be configured to perform any of a variety of checks during operation. For example, the rotation of the blade may be monitored by known mechanisms and the firing system may be disabled when the blade is not moving. This would allow the user to touch the blade when it is stopped without engaging brake mechanism 28. Various exemplary embodiments and implementations of a blade motion detection system are described in U.S. Provisional Application entitled Motion Detection System for Use in Safety System for Power Equipment, filed August 14, 2000, by SD3, LLC.

It will appreciated that many variations on the logic sequence described above may be implemented within the scope of the invention. For example, some embodiments of logic controller 50 may include a battery, a capacitor or other charge storage device to ensure the detection and reaction subsystems will continue to function at least temporarily after power to the machine is turned off. As another example, power to the motor assembly may be shut off if an error occurs other than contact detection such as incorrect blade-to-charge plate spacing, insufficient charge on the charge storage devices, etc. Thus, logic controller 50 may be implemented to provide any of a variety of safety and/or operational functions as desired.

Additionally, since reaction subsystem 24 is configured to stop cutting tool 14 upon contact with a user's body, it may also be desirable to stop motor assembly 16, or at least the portion of the motor assembly adapted to drive the cutting tool, to prevent damage to the motor as it tries to drive the stalled cutting tool. However, since machine 10 typically is designed with the expectation that the cutting tool may stop due to binding, etc., it will usually be sufficient to turn off the motor assembly within a few seconds. This can be accomplished simply by cutting power to the motor. For example, when machine 10 includes a magnetic contactor switch 48, the logic controller may be adapted to interrupt the circuit holding the magnetic contactor closed so that power to the motor is interrupted. It should be understood that this step is optional, in that interrupting power to the machine's motor assembly is neither necessary nor sufficient to prevent serious injury to the user when the user touches the machine's cutting tool. Therefore, the principal benefit of this step is to reduce the likelihood of damaging the motor assembly or drive system while the brake system is preventing rotation or other movement of the cutting tool. It will be appreciated that there are many other suitable ways of stopping motor assembly 12 which are within the scope of the invention. As one example, power to the motor assembly may be controlled directly by safety stop 30 (e.g., through solid state on/off switches, etc.). This embodiment is described in more detail in U.S. Provisional Application entitled Contact Detection System for Power Equipment, filed August 14, 2000, by SD3, LLC. Also, it is possible to simply allow existing overload circuitry to trip in and turn off the stalled motor.

Since the contact detection subsystem described above relies on certain electrical properties of the human body, the use of safety system 18 while cutting some materials, such as foil-coated insulation, may cause the detection circuitry to falsely register contact with a user. In addition, as described in U.S. Provisional Application entitled Contact Detection System for Power Equipment, filed August 14, 2000, by SD3, LLC, extremely green wood may cause false triggers in some types of detection subsystems due to the relatively high dielectric constant of green wood. Therefore, it may be desirable to provide a manual bypass or override control that prevents the brake from operating for a particular cutting operation. A suitable override control may include a mechanical switch between fusible member 70 and firing system 76. Alternatively, the switch may be a

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single-use switch configured to reset itself after each use. As a further alternative, safety system 18 may include sensors adjacent the workpiece to detect the presence of foil, green wood, etc., and disable the reaction subsystem automatically. This latter alternative relieves the user of having to remember to disable and re-enable the brake system.

In any event, the override control may be configured in a variety of ways depending on the application and the level of safety desired. For example, the override control may be configured to time-out (i.e., turn off), if the user does not switch the machine on within a predetermined time (e.g., 3, 5 or 10 seconds, etc.). This would prevent the user from actuating the override control and then becoming distracted before proceeding to cut the workpiece and forgetting the safety system had been disabled. In some embodiments, it may be desirable to allow a user to override the error caused by a failed self-test (e.g., no fusible member, insufficient stored charged, missing or incorrectly installed cartridge 80, etc.). In other embodiments, logic controller 50 may be configured to require that the detection and reaction subsystems are operational before allowing the user to override any errors.

Typically, the override control is configured to reduce the likelihood that it will be actuated accidentally by the user. For example, the override control switch may be located away from the remaining operator switches and away from an area on machine 10 where the user is likely to accidentally bump against while using the machine. Alternatively or additionally, override control switch 48 may include a cover or similar barrier which the user must remove or overcome before the switch can be actuated. Such covered switches are known to those of skill in the art. As an additional safety measure, logic controller 50 may be configured to produce a visual and/or audible alarm or warning when the override is actuated. Furthermore, where logic controller 50 is adapted to control the supply of power to motor assembly 16, the logic controller may be configured to "pulse" the motor one or more times to alert the user that the blade is about to begin moving with the safety system disabled. This would alert a user, who accidentally actuated the override while in contact with the blade, to quickly move away from the blade.

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In view of the above considerations, an alternative embodiment of logic controller 50 may be configured to perform the self-test and detection logic shown schematically in Figs. 4A-C. The main logic sequence, indicated generally at 910 in Fig. 4A, begins when machine 10 is first connected to power source 20, as indicated at 911. Logic controller 50 begins sequence 910 by performing a system integrity check, as indicated at 912. The system integrity check may include any one or more of a variety of checks which typically will vary depending on the particular type and configuration of machine 10. In the exemplary embodiment, system integrity check 912 includes testing the sufficiency of power source 20 (here, standard line current) by any suitable means which are known to those of skill in the art. The system integrity check may also include driving the detection signal onto charge plate 44 and attempting to detect the signal at charge plate 46. Failure to detect the detection signal at charge plate 46 may indicate a number of problems such as an electronic failure in detection subsystem 22, a mis-positioned or grounded charge plate, grounded blade, etc. Exemplary system integrity check 912 also includes a pawl-to-blade spacing test to ensure that pawl 60 is properly positioned adjacent blade 40 so that the pawl will engage and stop the blade if released. Exemplary mechanisms for detecting correct blade-to-pawl spacing are described in more detail below. If any of the tests performed during system integrity check 912 is negative, logic controller turns motor assembly 16 off (if on), as indicated at 913, and outputs an error signal to the user, as indicated at 914. Once the user corrects the error and resets the logic controller (e.g., by disconnecting and then reconnecting the power to machine 10), the system integrity check is repeated.

If system integrity check 912 is successful, logic controller 50 proceeds to check fusible member 70 as well as the stored charge in firing subsystem 76, as indicated at 915. If either the fusible member test or the stored charge test is negative, the logic controller turns off the motor assembly, indicated at 913, and then outputs an error signal, indicated at 914. It may be desirable to repeat step 915 one or more times, or provide a delay between steps 912 and 915 to ensure that firing subsystem 76 has sufficient time to build up the electrical charge.

If both the fusible member and firing subsystem tests are successful, logic controller then proceeds to one of two operational loops depending on whether the user-operable override switch has been activated, as indicated at 916. It will be appreciated that testing for a user override signal after performing the fusible member/charge storage test prevents a user from overriding safety system 18 unless the safety system is functional. Thus, for example, if a contact detection occurs and the brake is triggered, the user cannot proceed to operate the system until the fusible member, and/or pawl, and/or firing subsystem, etc., is replaced (typically by replacing cartridge 80). Alternatively, step 915 may be eliminated from the main operational loop. This would allow machine 10 to be operated regardless of whether safety system 18 was completely functional by engaging the override.

In any event, if the override has been actuated, logic controller 50 proceeds to operate in an override loop, as indicated at 917 and detailed in Fig. 4B. Typically, logic controller 50 first outputs a warning signal, as indicated at 918 and described above. Next, at step 919, the logic controller checks the status of START switch 48, which is operable by a user to turn on motor assembly 16. As described above, logic controller may be configured to read START switch 48 as being "on" only if it is actuated within a predetermined period after the override is enabled. If the START switch is "off," logic controller 50 turns off the motor assembly (if on), as indicated at 920, and exits the override loop as indicated at 921. As shown in Fig. 4A, the logic controller returns to the system integrity check at the end of the override loop. Thus, the logic controller will continue to perform the system integrity check and the fusible member/stored charge tests until the START switch is actuated. This ensures that if a user engages the override and then delays actuating the START switch, the system will not turn on the motor assembly if a failure occurs between the time the override is enabled and the time the START switch is actuated.

If, at step 919, the START switch is on, logic controller proceeds to turn on motor assembly 16, as indicated at 922. The motor assembly remains on until STOP switch 48 is actuated by the user, as indicated at 923. Once the STOP switch is actuated, logic

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controller 50 turns off the motor assembly, as indicated at 920, and exits the override loop at 921. As mentioned above, logic controller returns to step 912 after exiting the override loop.

If, at step 916, the override has not been engaged by the user, logic controller 50 proceeds to the detection loop 925, which is shown in detail in Fig. 4C. In the exemplary embodiment, detection loop 925 is depicted with two logic paths which are executed simultaneously. In a first path 926 the logic controller monitors detection subsystem 22, while in a second path 927 the logic controller continually rechecks the fusible member and stored charge in firing subsystem 76. This dual-path operation ensures that machine 10 will be shut down if a failure occurs while the blade is in motion. It will be appreciated by those of skill in the art that the dual-path operation may be implemented in a variety of ways including the use of interrupts, state machines, etc. Alternatively, the two paths may be implemented in a single sequential loop. However, since testing of the stored charge consumes several milliseconds or even several seconds in some embodiments, it is typically desirable, in those embodiments, to execute both paths simultaneously so that several milliseconds or more do not pass between successive contact detection measurements.

Path 927 includes testing fusible member 70 and the charge stored by firing subsystem 76, as indicated at 928. This test is continuously repeated unless and until either the fusible member test or the stored charge test fails, at which point logic controller 50 turns the motor assembly off, as indicated at 929, and outputs an error message, as indicated at 930. The logic controller also stops executing test 928 when it exits the detection loop or when an error in path 926 occurs, as described below. The tests of fusible member 70 and firing subsystem 76 at step 928 may be the same as, or different than, the tests that are used in the main loop at step 915. In any event, the logic controller must be reset from step 930, as described above.

Path 926 is the contact detection path and includes testing for excessive impedance loading on the blade, as indicated at 931. Step 931 ensures that power will not be supplied to the motor assembly if the capacitive load on the blade is so high that the detection subsystem might not be able to detect a contact between the blade and the user. This might occur for a variety of reasons. For example, if the blade is cutting highly dielectric materials (e.g., green wood), the capacitive load on the blade will increase. This issue is described in more detail in CASE 1.

As another example, the user might accidentally actuate the START switch while in contact with the blade. Since some exemplary detection subsystems rely on a sudden change (rather than an absolute level) in the signal detected at charge plate 46, step 931 ensures that the safety system will not allow the blade to begin rotating if the user is touching the blade when the START switch is actuated. In this embodiment, the logic controller is configured to set the value for excessive capacitive loading at approximately at least that amount of loading caused when a user contacts the blade. However, it will be appreciated that it is within the scope of the invention to configure logic controller 50 to recognize any desired amount of capacitive loading as being excessive.

If the capacitive load on the blade is too high, logic controller 50 outputs an error signal, at 932, and turns off motor assembly 16 (if on), as indicated at step 933. The logic controller then exits the detection loop, at 934, and returns to system integrity check 912 in the main operational loop shown in Fig. 4A. It will be appreciated that safety system 18 will not be enabled during the several seconds it takes the blade to spin down. This is because the capacitive loading is too high to accurately detect contact with the user, and is likely to trigger even though no contact has occurred. In alternative embodiments, the logic controller may continue to monitor for contact detection while the blade is rotating and actuate the firing system if contact is detected. Alternatively, the logic controller may be configured to actuate the firing system if the loading becomes too high.

Once the logic controller returns to the main loop after detecting a high capacitive loading error, the user may nevertheless operate machine 10 by engaging the override. If the user does not actuate the override, safety system 18 will not supply power to motor assembly 16 until the capacitive loading problem is corrected.

If, at step 931, the capacitive loading on the blade is within defined limits, the logic controller proceeds to test the contact detection signal from detection subsystem 22,

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as indicated at 935. If contact is detected, the logic controller determines whether the blade is rotating, as indicated at 936. If the blade is rotating, the logic controller actuates the firing subsystem, at 937, turns off motor assembly 16, at 929, and outputs an error, at 930. The logic controller must then be reset as described above.

However, if the blade is not rotating at step 936, then the logic controller outputs an error signal, at step 932, turns off the motor assembly (if on), at 933, and exits the detection loop, at 934. Thus, if a user touches the blade when it is not rotating, the safety system will detect the contact but will not actuate the firing subsystem. This allows a user to change or adjust the blade without actuating the brake. However, the user would typically remove power from machine 10 before adjusting or replacing the blade, in which case, neither safety system 18 nor motor assembly 16 would be operable.

If no contact is detected at step 935, logic controller 50 checks the status of STOP switch 48, as indicated at 938. If the STOP switch is actuated, the logic controller turns off the motor assembly (if on), as indicated at 939, and checks for blade rotation, as indicated at 940. If the blade is rotating, the logic controller loops back to step 931 so that the contact detection is active as long as the blade continues to rotate. Thus, if a user actuates the STOP switch and then contacts the blade before it spins down, safety system 18 will react to stop the blade. Once the blade ceases to rotate, the logic controller exits the detection loop, as indicated at 934.

If the STOP switch has not been actuated at step 938, the logic controller checks the status of START switch 48, as indicated at 941. If the START switch has been actuated, the logic controller turns the motor assembly on (if off), and loops back to repeat the contact detection, as indicated at 942. If the START switch has not been actuated, the logic controller turns off the motor assembly (if on), as indicated at 939, and checks for blade rotation, at 940. The logic controller continues to execute the detection loop until the blade stops, at which point the logic controller exits the detection loop, as indicated at 934. Thus, the logic controller is configured to continuously monitor for contact detection whenever the blade is rotating and the user has not engaged the override.

Those of skill in the art will appreciate that control subsystem 26 and logic controller 50 may be implemented using many different components and many different configurations. Therefore, while two exemplary implementations are described below, it should be understood that any other suitable implementation is also within the scope of the invention.

A first exemplary implementation is illustrated schematically in Fig. 5. Logic controller 50 takes the form of a PIC16C63A-20/SO controller available from Microchip Technology, Inc., of Chandler, Arizona. The logic controller is coupled to power source 20, contact detection subsystem 22, and a user interface 178. The user interface may include any suitable mechanism adapted to display signals to a user and to allow a user to input signals to the logic controller. Examples of suitable user interface mechanisms which are known to those of skill in the art include lights, display screens, buzzers, sirens, switches, buttons, knobs, etc. In one exemplary embodiment depicted in Fig. 6, user interface 178 includes START, STOP, and OVERRIDE switches to allow the user to input control commands, and a pair of LED lights which indicate the system status. The LED lights may indicate system status in a variety of ways such as color, blinking, etc.

The logic controller is also connected to control motor assembly 16 via a suitable motor control circuit 174, such as is described in more detail in U.S. Provisional Application entitled Contact Detection System for Power Equipment, filed August 14, 2000, by SD3, LLC, and to firing subsystem 76. When the logic controller receives a signal from detection subsystem 22 that contact between the user and blade has occurred, the logic controller actuates firing subsystem 76 and stops motor assembly 16. The operation and testing sequences are implemented by software instructions stored within, and executable by, the logic controller. It will be appreciated that the software instructions may take a variety of forms. One set of software instructions suitable for use with the PIC16C63A-20/SO controller, as well as function flowcharts, are provided in Appendix A.

The logic controller of the exemplary implementation depicted in Fig. 5 is configured to conduct a variety of self-tests before enabling power to motor control 174,

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as well as whenever the blade is moving. For example, the logic controller is configured to evaluate the line voltage supplied by power source 20, and to shut off the motor if the voltage drops below a minimum value sufficient to operate the safety system. The logic controller is also adapted to test the contact sense signal received from the detection subsystem to ensure the charge plates are correctly positioned, that the detection signal is properly coupled across the blade, and that the capacitive load on the blade is within defined limits. Further, the logic controller is also coupled to a blade rotation sense component 177. Examples of suitable mechanisms for detecting blade rotation are described in U.S. Provisional Application entitled Motion Detection System for Use in Safety System for Power Equipment, filed August 14, 2000, by SD3, LLC.

In addition, logic controller 50 is also adapted to detect whether firing subsystem 76 has sufficient stored charge to melt fusible member 70. It will be appreciated that detection of sufficient stored charge in the firing subsystem may be carried out in a variety of ways depending on the configuration of the firing system. In each of the exemplary implementations described herein, firing subsystem 76 includes a single 390μF firing capacitor 620 configured to discharge through fusible member 70 via a suitable SCR 621 connected to ground. Exemplary firing subsystems 76 are described in greater detail in U.S. Provisional Application entitled Firing Subsystem for Use in a Fast-Acting Safety System, filed August 14, 2000, by SD3, LLC.

In the implementation depicted in Fig. 5, the firing capacitor is both charged and tested by a buck-boost regulator 175, which is shown in greater detail in Fig. 7. Buck-boost regulator 175 includes a buck-boost charger 183 that steps up an 32-volt supply input to 180 volts for charging the firing capacitor. Logic controller 50 provides a 125khz input to control the buck-boost cycle of the charger. A regulator circuit 184 monitors the voltage on the firing capacitor and turns charger 183 on or off as necessary to maintain the charge near 180 volts. Regulator circuit 184 is constructed with a predetermined amount of hysteresis so that the charger will go on when the firing circuit voltage falls below 175 volts and turn off when the voltage reaches 180 volts, as set by the voltage divider inputs and feedback to comparator 185.

The output of comparator 185 is fed to logic controller 50. The logic controller monitors both the time required to charge and to discharge the firing capacitor based on the state of the output of comparator 185. Thus, the controller can verify that the firing capacitor is operating properly and storing adequate charge. If the firing capacitor cannot reach 180 volts quickly enough or discharges too rapidly, the logic controller determines that the firing capacitor or charging system has failed and takes appropriate action based on its programming.

It should be noted that regulator circuit 184 measures the voltage across the firing capacitor through fusible member 70. As a result, the regulator circuit is also testing the integrity of the fusible member since a missing or failed fusible member would prevent the regulator circuit from detecting the voltage on the firing capacitor. While testing both the firing capacitor charge and fusible member with a single mechanism or test provides obvious savings of both processor cycle time and component costs, the fusible member may alternatively be tested separately from the firing capacitor charge within the scope of the invention.

A second exemplary implementation of logic controller 50 is illustrated schematically in Fig. 8. Logic controller 50 is implemented by a 87C752 controller available from Philips Semiconductor of Sunnyvale, California As in the first exemplary implementation described above, the logic controller of the second implementation is coupled to power source 20, contact detection subsystem 22, firing subsystem 76, user interface 178, motor control 174, and blade rotation sense 177. Suitable examples of power source 20, contact detection subsystem 22, and motor control 174 are described in more detail in U.S. Provisional Application entitled Contact Detection System for Power Equipment, filed August 14, 2000, by SD3, LLC. Exemplary firing subsystems 76 are described in more detail in U.S. Provisional Application entitled Firing Subsystem for Use in a Fast-Acting Safety System, filed August 14, 2000, by SD3, LLC. Exemplary circuitry and mechanisms for sensing blade rotations are described in more detail in U.S. Provisional Application entitled Motion Detection System for Use in Safety System for Power Equipment, filed August 14, 2000, by SD3, LLC.

As shown in Fig. 9, the firing capacitor charging circuit for the second implementation is regulated by an enable line from logic controller 50. By deactivating the charging circuit, the logic controller can monitor the capacitor voltage through an output to an analog-to-digital converter (A/D) line on the logic controller. When the capacitor is not being charged, it will normally discharge at a relatively known rate through the various paths to ground. By monitoring the discharge rate, the controller can insure that the capacitance of the capacitor is sufficient to burn the fusible member. Optionally, the logic controller may be configured to measure the voltage on the firing capacitor at a plurality of discharge intervals to evaluate the integrity of the capacitor. In one embodiment, the logic controller measures the capacitor voltage at three defined intervals during a discharge cycle, which should correspond to 3%, 5% and 7% of the full charge voltage. The logic controller may be configured to interpret a low voltage at any of the discharge intervals as a failure, or may require a low voltage at two or more discharge intervals to indicate a failure.

As with the first exemplary implementation described above, the logic controller is configured to test the firing capacitor through fusible member 70, thereby simultaneously testing the fusible member. Alternatively or additionally, the logic controller may test the fusible member independently of the capacitor by monitoring the capacitor voltage during charging.

As mentioned above, logic controller 50 may also be configured to monitor the pawl-to-blade spacing. It is well known in the art that many cutting tools such as saw blades do not have precisely uniform dimensions. As a result, when a new blade is installed on a saw, the pawl may no longer be correctly spaced from the blade. An incorrectly positioned pawl may slow the stopping speed of the pawl or prevent the pawl from stopping the blade. Therefore, to ensure the blade is stopped with uniform braking speed, it may be necessary to adjust the position of the pawl whenever a blade is replaced. Exemplary mechanisms and methods for automatically positioning the pawl are described in U.S. Provisional Application entitled Brake Positioning System, filed August 14, 2000, by SD3, LLC. However, regardless of whether the pawl is automatically positioned, configuring logic controller 50 to detect incorrect blade-to-pawl spacing provides an additional level of assurance that a user is protected against accidental contact with the blade.

It will be appreciated that there are many ways in which incorrect spacing between blade 40 and pawl 60 may be detected. As one example, Fig. 10 illustrates a pawl 945 having a capacitive system for detecting correct pawl spacing. Similar to pawl 40 shown in Fig. 2, pawl 945 may include a portion 946 that is beveled or otherwise shaped to quickly and completely engage the teeth of a cutting tool. In addition, pawl 945 includes a pair of generally parallel, spaced-apart arms 947 which extend beyond portion 946. Arms 947 are disposed to extend on either side of the blade, without touching the blade, when the pawl is in place adjacent the blade. Each arm includes a capacitor plate 826 disposed on the inside surface of the arm adjacent the blade. Conductive leads 949 run from each capacitor plate 826 to suitable blade detector circuitry (not shown).

Capacitor plates 826 are positioned on arms 947 such that, when the pawl spacing is within a desired range, the blade extends between the two capacitor plates. It will be appreciated that the capacitance across plates 826 will vary depending on whether the blade is positioned between the plates. The blade detector circuitry is configured to drive an electrical signal through conductive leads 949 and detect changes in the capacitance across the plates.

Suitable circuitry that may be used with pawl 945 is well known to those of skill in the art. One exemplary pawl-to-blade spacing detection circuit is indicated generally at 824 in Fig. 11. As described above and in U.S. Provisional Application entitled Contact Detection System for Power Equipment, filed August 14, 2000, by SD3, LLC, and U.S. Provisional Application entitled Apparatus and Method for Detecting Dangerous Conditions in Power Equipment, filed August 14, 2000, by SD3, LLC, one exemplary contact detection system suitable for use with the present invention applies an electrical signal to the blade via a drive plate (not shown). This signal can be picked up by either or both of plates 826 and monitored to insure that it has an amplitude in a predetermined range. In particular, the amplitude detected by plates 826 will fall off rapidly with

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distance from the blade. Therefore, by monitoring the detected amplitude, proper spacing can be verified. If the proper signal is not detected, circuit 824 conveys an error signal to logic controller 50, which prevents operation of machine 10 until proper pawl-to-blade spacing is detected. Other examples include circuits similar to the exemplary contact detection circuits described in U.S. Provisional Application entitled Contact Detection System for Power Equipment, filed August 14, 2000, by SD3, LLC.

Capacitor plates 826 can optionally be shaped to detect when the pawl is too close to the blade as well as not close enough. Alternatively, two pairs of capacitor plates may be positioned on the pawl: one pair to detect if the pawl is too close to the blade, and the other pair to detect if the pawl is too far from the blade. In any event, the detector circuitry is configured to transmit an error signal to logic controller 50, which then takes appropriate action.

While one exemplary automatic pawl spacing detection system has been described above, it will be appreciated that there are many possible variations within the scope of the invention. For example, both capacitor plates may be positioned on the same side of the blade rather than on opposite sides. The capacitor plates and/or blade detection circuitry may be separate from the pawl. In the latter case, for example, the capacitor plates and detection circuitry may be mounted on a separate electronics board associated with the pawl. Alternatively, the capacitor plates may be replaced with one or more light-emitting diodes and detectors such that, when the pawl is properly positioned, the blade obstructs the optical path between the diodes and detectors. Other methods of detecting the proximity of the blade to the pawl are also possible. As a further option, capacitor plates 826 may function as charge plates 44, 46 as well as pawl-spacing detectors. In addition, a detection plate may be mounted on beveled face 946 of the pawl. This plate can be used to detect the drive input signal used for contact detection. The amplitude of the signal detected at the plate will be inversely proportional to the space between the plate and the teeth of the blade. If this signal does not have an amplitude over a given threshold, the system would interpret this as indicating that the pawl face is not close enough to the blade.

In embodiments where portions of safety system 18 are mounted in a replaceable cartridge 80, logic controller may also be configured to detect whether the cartridge is properly connected to the remainder of the safety system. One exemplary method of testing for an operable connection with the cartridge is by testing a component mounted in the cartridge (e.g., the fusible link, charge stored by firing system, etc.). Alternatively, a cable (not shown) connecting cartridge 80 to logic controller 50 may include a separate signal line which is grounded or otherwise biased when the cartridge is connected. In addition to detecting an operable connection to the cartridge, the correct blade-to-pawl spacing may be detected by measuring the blade-to-cartridge spacing. For example, capacitor plates 826 may be placed on cartridge housing 82 rather than on the pawl itself. Furthermore, failure of the blade-to-cartridge spacing test could also be used to detect an inoperable connection to the cartridge.

As described above, the present invention provides a reliable, effective and fast-acting system for preventing serious injuries to operators of power cutting machinery. While a few specific embodiments of safety system 18 and particularly control subsystem 26 have been described, those of skill in the art will appreciated that the present invention may be adapted in numerous ways for use in a wide variety of applications. Therefore, it will be understood that all such adaptations and applications are within the scope of the invention.

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 subcombinations 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.

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;*****************************************************************
;                         SAWBRK.ASM
;              Control Program for Benchsaw Brake
;          Written By: Bob Chamberlain, 29 June, 2000
;
;*****************************************************************
;
;
        LIST    p=16C63a        ; PIC16C63a is the target processor
;
        include <p16c63a.inc>   ; Standard definitions for PIC16C63a
;
;*****************************************************************
;       Local GP register definitions
;
TMR100  equ     H'0020' ; 100mS software timer
TMR200  equ     H'0021' ; 200mS software timer
TMR500  equ     H'0022' ; 500mS software timer
STMRA   equ     H'0023' ; Software Timer A, nominally 1 Sec.
STMRB   equ     H'0024' ; Software timer B, nominally 4 Sec.
STMRC   equ     H'0025' ; Software Timer C, nominally 10 Sec.
COUNT   equ     H'0026' ; Stored value from Timer 0
XDATA   equ     H'0027' ; UART XMT Data, either Hex 88 or FF
TRIGFL  equ     H'0028' ; Flag - a transition on TRIG_SENSE occurred
UNCALFL equ     H'0029' ; Flag - sense circuit is out of calibration
CHRGFL  equ     H'002A' ; Flag - trigger cap is in charge cycle
TMRFL   equ     H'002B' ; Flag - 100mS timer has overflowed
SMRUN   equ     H'002C' ; Flag - Running
SMBPS   equ     H'002D' ; Flag - Running in Bypass Mode
WTBPS   equ     H'002E' ; Flag - Waiting for Bypass Mode
WTSTP   equ     H'002F' ; Flag - Waiting for blade to stop
ARMFL   equ     H'0030' ; Flag - saw brake armed
PWMFL   equ     H'0031' ; Flag - process PWM duty cycle
PWMUP   equ     H'0032' ; Flag - last PWM correction direction was up
PWMDN   equ     H'0033' ; Flag - last PWM correction direction was down
HSENSE  equ     H'0034' ; Flag - Hall sensor not functioning
INTFACT equ     H'0035' ; Integration factor for PID Regler
WSAV    equ     H'0036' ; Saved W register
SSAV    equ     H'0037' ; Saved Status register
PWMHI   equ     H'0038' ; Saved PWM duty cycle - MSB
PWMLO   equ     H'0039' ; Saved PWM duty cycle - 8 LSB's
BITBHI  equ     H'003A' ; Blink rate register for self-test - high byte
BITBLO  equ     H'003B' ; Blink rate register for self-test - low byte
MTREG   equ     H'003C' ; Min discharge time register
PARMFL  equ     H'003D' ; Flag - ARMFL should be set if supplies in regulation
PARMTO  equ     H'003E' ; Flag - Initial arming timeout has passed
LVTMR   equ     H'003F' ; 2 second low voltage software timer
TEMP    equ     H'0040' ; Scratchpad register, various uses
OPTREG  equ     H'0081' ; OPTION register
;
;*****************************************************************
;       Local constant definitions
;
OPTVL   equ     H'00FF' ; Preload value for OPTION register
                        ;   MSB 7 RBPU/  Port B pullups disabled
                        ;       6 INTEDG Int. on rising edge of RB0
                        ;       5 TOCS   TMR0 clock from pin RA4
                        ;       4 TOSE   Inc. TMR0 on falling edge
                        ;       3 PSA    Assigns prescaler to WDT
                        ;       2 Prescaler MSB \
                        ;       1                > Set to / by 128
                        ;   LSB 0 Prescaler LSB /
ICONA   equ     H'00C8' ; Preload value for INTCON register
                        ;   MSB 7 GIE   Global interrupt enabled
                        ;       6 PEIE  Peripheral interrupts enabled
                        ;       5 TOIE  TMR0 interrupt disabled
                        ;       4 INTE  RB0/INT ext. int. disabled
                        ;       3 RBIE  Port B int. on change enabled
                        ;       2 TOIF  Timer 0 overflow flag
                        ;       1 INTF  RB0/INT flag
                        ;   LSB 0 RBIF  Port B change flag
ICONB   equ     H'00D8' ; Preload value for INTCON register w/RB0 Int.
                        ;   MSB 7 GIE   Global interrupt enabled
                        ;       6 PEIE  Peripheral interrupts enabled
                        ;       5 TOIE  TMR0 interrupt disabled
                        ;       4 INTE  RB0/INT ext. int. enabled
                        ;       3 RBIE  Port B int. on change enabled
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                                 ;        2 TOIF  Timer overflow flag
                                 ;        1 INTF  RB0/INT flag
                                 ;    LSB 0 RBIF  Port B change flag
ICONC    equ       H'00C0'    ; Preload value for INTCON regist[illegible] w/UART and Timer 1
                                      MSB 7 GIE   Global interrupt [illegible]bled
                                 ;        6 PEIE  Peripheral interrupts enabled
                                 ;        5 TOIE  TMR0 interrupt disabled
                                 ;        4 INTE  RB0/INT ext. int. disabled
                                 ;        3 RBIE  Port B int. on change disabled
                                 ;        2 TOIF  Timer overflow flag
                                 ;        1 INTF  RB0/INT flag
                                 ;    LSB 0 RBIF  Port B change flag
PIE1LD   equ       H'0011'    ; Preload value for PIE1 register
                                 ;    MSB 7 Reserved
                                 ;        6 Reserved
                                 ;        5 RCIE  UART Receive Int. disabled
                                 ;        4 TXIE  UART Transmit Int. enabled
                                 ;        3 SSPIE SSP Interrupt disabled
                                 ;        2 CCP1IE CCP1 Interrupt disabled
                                 ;        1 TMR2IE TMR2 Match Int. disabled
                                 ;    LSB 0 TMR1IE TMR1 Overflow Int. enabled
PRTA     equ       H'003F'    ; Preload value for TRISA
                                 ;    MSB 7 Not used
                                 ;        6 Not used
                                 ;        5 RA5 OVRVLT - input
                                 ;        4 RA4 CAL_SENSE - TMR0 clock input
                                 ;        3 RA3 CAP_THRESH - input
                                 ;        2 RA2 Bypass Switch - input
                                 ;        1 RA1 Stop Switch - input
                                 ;    LSB 0 RA0 Start Switch - input
PRTB     equ       H'0013'    ; Preload value for TRISB
                                 ;    MSB 7 RB7 - Not used - output
                                 ;        6 RB6 - Not used - output
                                 ;        5 RB5 - Not used - output
                                 ;        4 RB4 - TRIG_SENSE - input (IOC)
                                 ;        3 RB3 - Not used - output
                                 ;        2 RB2 - Not used - output
                                 ;        1 RB1 - Low Voltage Sense - input
                                 ;    LSB 0 RB0 - Ext. Int. - input (Hall Sensor)
PRTC     equ       H'0000'    ; Preload value for TRISC
                                 ;    MSB 7 RC7 - UART Data - output
                                 ;        6 RC6 - UART Clock - output
                                 ;        5 RC5 - Not used - output
                                 ;        4 RC4 - SCR Trigger - output
                                 ;        3 RC3 - Motor On - output
                                 ;        2 RC2 - PWM - output
                                 ;        1 RC1 - Green LED - output
                                 ;    LSB 0 RC0 - Red LED - output
PRTC2    equ       H'0010'    ; Preload value for TRISC, Trigger HiZ
                                 ;    MSB 7 RC7 - UART Data - output
                                 ;        6 RC6 - UART Clock - output
                                 ;        5 RC5 - Not used - output
                                 ;        4 RC4 - SCR Trigger - input (HiZ)
                                 ;        3 RC3 - Motor On - output
                                 ;        2 RC2 - PWM - output
                                 ;        1 RC1 - Green LED - output
                                 ;    LSB 0 RC0 - Red LED - output
TMR1CON equ       H'0001'    ; Timer 1 Configuration
                                 ;    MSB 7 Not used
                                 ;        6 Not used
                                 ;        5 T1CKPS1 - Prescaler MSB\
                                 ;                                  > div. by 1
                                 ;        4 T1CKPS0 - Prescaler LSB/
                                 ;        3 T1OSCEN - Oscillator disabled
                                 ;        2 T1SYNC - Not used - internal clock
                                 ;        1 TMR1CS - Use Internal Clock - 200nS
                                 ;    LSB 0 TMR1ON - Start Timer
TMR2CON equ       H'0004'    ; Timer 2 Configuration
                                 ;    MSB 7 Not used
                                 ;        6 TOUTPS3 - Postscaler MSB\
                                 ;        5 TOUTPS2 - Postscaler     \
                                 ;                                    > div. by 1
                                 ;        4 TOUTPS1 - Postscaler     /
                                 ;        3 TOUTPS0 - Postscaler LSB/
                                 ;        2 TMR2ON - Starts Timer
                                 ;        1 T2CKPS1 - Prescaler MSB\
                                 ;                                  > div. by 1
```

```
                          ;   LSB 0 T2CKPS0 - Prescaler LSB/
PWM1CON equ     H'000C'   ; CCP1 Configuration as PWM Timer
                          ;   MSB 7 Not used
                          ;       6 Not used                \
                          ;       5 CCP1X - PWM Duty Cycle   . LSB.
                          ;       4 CCP1Y - PWM Duty Cycle LSB
                          ;       3 CCP1M3 - Mode MSB\
                          ;       2 CCP1M2 - Mode     \
                          ;                            > PWM Mode
                          ;       1 CCP1M1 - Mode     /
                          ;   LSB 0 CCP1M0 - Mode LSB/
UARTTX  equ     H'00B0'   ; UART TX Configuration
                          ;   MSB 7 CSRC - Use clock from BRG
                          ;       6 TX9 - 8 bit transmission
                          ;       5 TXEN - Transmit enabled
                          ;       4 SYNC - Synchronous mode
                          ;       3 Not used
                          ;       2 BRGH - Not used
                          ;       1 TRMT - Read only
                          ;   LSB 0 TX9D - XMT bit 9 - Not used
UARTRX  equ     H'0080'   ; UART RX Configuration
                          ;   MSB 7 SPEN - UART Function selected
                          ;       6 RX9 - 8 bit reception
                          ;       5 SREN - Single Receive disabled
                          ;       4 CREN - Cont. Receive disabled
                          ;       3 Not used
                          ;       2 FERR - Read only
                          ;       1 OERR - Read only
                          ;   LSB 0 RX9D - RCV bit 9 - Not used
ONE     equ     H'0001'   ; Constant value 1
BAUDRG  equ     H'0009'   ; Set Baud Rate to 500kHz
PWMPER  equ     H'00FF'   ; Set PWM period to 51.2uS
PWMDC   equ     H'00B3'   ; Set initial duty cycle to 70%
PWMLOPL equ     H'00CC'   ; Preload for PWMLO - 4 times PWMDC (8 LSB's)
T1HIGH  equ     H'00F8'   ; Set Timer 1 high byte for 400uS
T1LOW   equ     H'0030'   ; Set Timer 1 low byte for 400uS
T100PL  equ     H'00FA'   ; 100mS Software Timer preload
MS200PL equ     H'0002'   ; 200mS Software Timer preload
MS300PL equ     H'0002'   ; 300mS Software Timer preload
MS500PL equ     H'0005'   ; 500mS Software Timer preload
S1PL    equ     H'000A'   ; 1 Sec Software Timer preload
S2PL    equ     H'0014'   ; 2 Sec Software Timer preload
S3PL    equ     H'001E'   ; 3 Sec Software Timer preload
S4PL    equ     H'0028'   ; 4 Sec Software Timer preload
S5PL    equ     H'0032'   ; 5 Sec Software Timer preload
S6PL    equ     H'003C'   ; 6 Sec Software Timer preload
S7PL    equ     H'0046'   ; 7 Sec Software Timer preload
S8PL    equ     H'0050'   ; 8 Sec Software Timer preload
S9PL    equ     H'005A'   ; 9 Sec Software Timer preload
S10PL   equ     H'0064'   ; 10 Sec Software Timer preload
CHRGON  equ     H'0088'   ; Data byte to charge trigger cap.
CHRGOFF equ     H'00FF'   ; Data byte to turn off charge
RLED    equ     H'0000'   ; Bit in Port C for red LED
GLED    equ     H'0001'   ; Bit in Port C for green LED
MOT     equ     H'0003'   ; Bit in Port C for saw motor
TRIG    equ     H'0004'   ; Bit in Port C for trigger signal
LVOLT   equ     H'0001'   ; Bit in Port B for low voltage detector
SWON    equ     H'0000'   ; Bit in Port A for start switch
SWOFF   equ     H'0001'   ; Bit in Port A for stop switch
SWBPS   equ     H'0002'   ; Bit in Port A for bypass switch
THRESH  equ     H'0003'   ; Bit in Port A for charge threshold
OVRVLT  equ     H'0005'   ; Bit in Port A for overvoltage threshold
WDTO    equ     H'0004'   ; WDT timed out bit in status register
DL100US equ     H'0022'   ; 100uS delay preload
LOWLIM  equ     H'0032'   ; Lower deadzone limit - 50
HILIM   equ     H'0096'   ; Upper deadzone limit - 150
MAXLIM  equ     H'00C6'   ; Max proportional limit - 198
MAXINT  equ     H'000A'   ; Maximum integrator value
MAXPWM  equ     H'00E0'   ; Max PWM duty cycle - 97%
MINPWM  equ     H'001F'   ; Min PWM duty cycle - 3%
MAXTIME equ     H'0032'   ; Max cap discharge remainder time - 5 S
MINTIME equ     H'0023'   ; Min cap discharge remainder time - 3.5 S
PWMMASK equ     H'007F'   ; Mask to clear MSB of PWM duty cycle
PWMORM  equ     H'0080'   ; Mask to set MSB of PWM duty cycle
BITER1  equ     H'0001'   ; 1-of-4 blink of red LED for self-test
BITER2  equ     H'0005'   ; 2-of-4 blink of red LED for self-test
BITER3  equ     H'0015'   ; 3-of-4 blink of red LED for self-test
```

```
BITER4   equ     H'0055' ; 4-of-4 blink of red LED for self-test
BITER5   equ     H'00FF' ; Solid red LED for self-test
;
;*****************************************************************
;        Program code
;
page0    org     H'0000' ; Entry point after reset
start    btfss   STATUS,WDTO ; Test if reset was caused by Watchdog
         goto    shutdn  ; Watchdog Timer timeout, shut saw down
         clrwdt          ; Normal reset, initialize the Watchdog Timer
         goto    main    ; Jump past ISR to main program
;
;*****************************************************************
;        Interrupt Service Routine
;
isr      org     H'0004' ; Entry point for ISR
         movwf   WSAV    ; Save W without status change
         swapf   STATUS,W ; Save STATUS without status change
         movwf   SSAV    ; Nibbles are swapped
;
;*****************************************************************
;        Test for Trigger Interrupt - 8µS Interval
;
tsttrg   btfss   INTCON,RBIF ; Test for Trigger transition
         goto    tstuart ; Not trigger, test UART TX int.
         movf    PORTB,W ; Read PORTB to clear mismatch
         bcf     INTCON,RBIF ; Clear interrupt flag
         clrf    TRIGFL  ; Clear trigger flag
;
;*****************************************************************
;        Restore W and STATUS register and return
;        Placed here out of sequence to save a GOTO (2 cycles)
;        in the highest frequency ISR
;
isrrtn   swapf   SSAV,W  ; Restore STATUS without status change
         movwf   STATUS  ; Nibbles are swapped back
         swapf   WSAV,F  ; Restore W without status change
         swapf   WSAV,W  ; Nibbles are swapped and then swapped back
         retfie
;
;*****************************************************************
;        Test for UART Transmit Interrupt - 16µS Interval
;
tstuart  btfss   PIR1,TXIF ; Test for UART TX interrupt
         goto    tsttmr  ; Not UART, test Timer 1 interrupt
         movf    XDATA,W ; Reload XMT register
         movwf   TXREG
         bcf     PIR1,TXIF ; Clear interrupt flag
         clrwdt          ; Reset Watchdog
;
;*****************************************************************
;        Test if trigger pulses were received within the last 16uS
;
         movf    TRIGFL,F ; Dummy move to set Z status bit
         btfsc   STATUS,Z ; Z bit set if flag clear (trigger pulses)
         goto    settfl  ; Clear, all OK, set flag for next cycle
         rrf     TRIGFL,W ; Shift LSB into C status bit
         btfsc   STATUS,C ; C bit clear if TRIGFL is non-zero and LSB is 0
         goto    settfl  ; Increment TRIGFL for another pass
         movf    ARMFL,F ; No trigger pulses, test armed flag
         btfss   STATUS,Z ; Z bit set if flag clear (not armed)
         call    sawtrg  ; Armed, shut down saw with brake
         clrf    TRIGFL  ; Not armed, set flag for next cycle
settfl   incf    TRIGFL,F ; All OK, set trigger flag for next cycle
         goto    isrrtn
;
;*****************************************************************
;        Test for Timer 1 Overflow - 400µS Interval
;
tsttmr   btfss   PIR1,TMR1IF ; Test for Timer 1 overflow
         goto    hallint ; Not Timer 1, must be Hall sensor interrupt
         movlw   T1HIGH  ; Reload Timer 1
         movwf   TMR1H
         movlw   T1LOW
         movwf   TMR1L
         bcf     PIR1,TMR1IF ; Clear interrupt flag
         movf    TMR0,W  ; Save Timer 0 count
```

```
        movwf   COUNT
        clrf    TMR0    ; Reset Timer 0
        bsf     PWMFL,0 ; Set process PWM duty cycle flag
        goto    isrrtn
;
;*******************************************************************
;       Process Hall Sensor Interrupt
;       The Hall Sensor interrupt is only enabled during the
;       wait for the saw blade to stop rotating after the stop
;       switch has been pressed.  The interval is one interrupt
;       per rotation of the arbor shaft.  The 1 S timer is reset
;       with this interrupt.  When 1 second has passed without an
;       interrupt, the wait cycle will end.  If the 1 S timer times
;       out without this interrupt being called, the Hall Sensor has
;       failed and the saw will be shut down.
;
hallint movlw   S1PL    ; Load Software Timer A for 1 second period
        movwf   STMRA
        clrf    HSENSE  ; Clear Hall sensor flag
        bcf     INTCON,INTF ; Clear interrupt flag
        goto    isrrtn
;
;*******************************************************************
;       System Subroutines
;*******************************************************************
;       Adjust PWM Duty Cycle Subroutine
;       PWM duty cycle is adjusted upwards to decrease drive
;       voltage and decrease value in COUNT register.  PWM
;       duty cycle is adjusted downwards to increase drive
;       voltage and increase value in COUNT register.
;       This subroutine implements an almost purely integrating
;       regulator.
;
adjpwm  clrf    UNCALFL ; Clear uncalibrated flag
        clrf    PWMFL   ; Clear flag that called this routine
        decfsz  TMR100,F ; Dec 100mS timer, set flag and reload on 0
        goto    ckcnt
        bsf     TMRFL,0 ; Set 100mS timeout flag
        movlw   T100PL  ; Reload 100mS timer
        movwf   TMR100
ckcnt   movf    COUNT,F ; Dummy move to set Z status
        btfss   STATUS,Z ; Z bit set if COUNT is 0
        goto    chklow  ; COUNT > 0, check lower deadzone limit
;
;*******************************************************************
;       COUNT = 0 - Adjust PWM down by INTFACT to increase amplitude
;
        movf    PWMUP,F ; Test if last correction direction was up
        btfss   STATUS,Z ; Z bit set if not up
        clrf    INTFACT ; Last direction up, clear INTFACT before increment
        incf    INTFACT,F ; Increment INTFACT by 3
        incf    INTFACT,F
        incf    INTFACT,F
        clrf    PWMUP   ; Clear PWMUP flag
        bsf     PWMDN,0 ; Set PWMDN flag
        movf    INTFACT,W ; Subtract INTFACT from PWMLO
        subwf   PWMLO,F
        btfss   STATUS,C ; C bit set if PWMLO does not underflow
        decf    PWMHI,F ; Decrement duty cycle MSBs on underflow
        btfsc   PWMHI,0 ; Test for duty cycle under 3%
        goto    incint  ; 2nd MSB set, duty cycle cannot be under 3%
        btfsc   PWMHI,1 ; Test for duty cycle under 3%
        goto    incint  ; MSB set, duty cycle cannot be under 3%
        movlw   MINPWM  ; Test PWMLO for duty cycle under 3%
        subwf   PWMLO,W
        btfsc   STATUS,C ; C bit clear if duty cycle is less than 3%
        goto    incint  ; Duty cycle greater than 3%
        movlw   MINPWM  ; Limit duty cycle to 3%
        movwf   PWMLO
        goto    incint
chklow  movlw   LOWLIM  ; Load lower deadzone limit into W
        subwf   COUNT,W ; Subtract from COUNT
        btfsc   STATUS,C ; C bit set if COUNT > or = lower deadzone limit
        goto    chkhi   ; COUNT > or = lower deadzone limit
;
;*******************************************************************
;       0 < COUNT < Lower Deadzone Limit - Adjust PWM down by 1
```

```
;
        clrf    INTFACT ; Set INTFACT to 1
        incf    INTFACT,F
        clrf    PWMUP   ; Clear PWMUP flag
        bsf     PWMDN,0 ; Set PWMDN flag
; Use SUBWF instead of DECF here to get carry status bit set
        movlw   ONE     ; COUNT is below lower deadzone limit
        subwf   PWMLO,F ; "Decrement" PWMLO
        btfss   STATUS,C ; C bit set if PWMLO does not underflow
        decf    PWMHI,F ; Decrement duty cycle MSBs on underflow
        btfsc   PWMHI,0 ; Test for duty cycle under 3%
        goto    setpwm  ; 2nd MSB set, duty cycle cannot be under 3%
        btfsc   PWMHI,1 ; Test for duty cycle under 3%
        goto    setpwm  ; MSB set, duty cycle cannot be under 3%
        movlw   MINPWM  ; Test PWMLO for duty cycle under 3%
        subwf   PWMLO,W
        btfsc   STATUS,C ; C bit clear if duty cycle is less than 3%
        goto    setpwm  ; Duty cycle greater than 3%
        movlw   MINPWM  ; Limit duty cycle to 3%
        movwf   PWMLO
        goto    setpwm
chkhi   movlw   HILIM   ; Load upper deadzone limit into W
        subwf   COUNT,W ; Subtract from COUNT
        btfsc   STATUS,C ; C bit set if COUNT > or = upper deadzone limit
        goto    chkmax  ; COUNT > or = upper deadzone limit
;
;*******************************************************************
;       Lower Deadzone Limit < COUNT < Upper Deadzone Limit - No Change
;
        clrf    INTFACT ; COUNT in deadzone, clear INTFACT
        clrf    PWMUP   ; Clear PWM correction direction flags
        clrf    PWMDN
        goto    pwmrtn
chkmax  movlw   MAXLIM  ; Load max limit into W
        subwf   COUNT,W ; Subtract from COUNT
        btfsc   STATUS,C ; C bit set if COUNT > or = max limit
        goto    ovrmax  ; COUNT > or = than max limit
;
;*******************************************************************
;       Upper Deadzone Limit < COUNT < Max Limit - Adjust PWM up by 1
;
        clrf    INTFACT ; COUNT < max limit, set INTFACT to 1
        incf    INTFACT,F
        bsf     PWMUP,0 ; Set PWMUP flag
        clrf    PWMDN   ; Clear PWMDN flag
        incf    PWMLO,F ; Increment 8 LSB's
        btfsc   STATUS,Z ; Z bit set on increment overflow
        incf    PWMHI,F ; Increment duty cycle MSBs on overflow
        btfss   PWMHI,0 ; Test for duty cycle over 97%
        goto    setpwm  ; 2nd MSB clear, duty cycle cannot be over 97%
        btfss   PWMHI,1 ; Test for duty cycle over 97%
        goto    setpwm  ; MSB clear, duty cycle cannot be over 97%
        movlw   MAXPWM  ; Test PWMLO for duty cycle over 97%
        subwf   PWMLO,W
        btfss   STATUS,C ; C bit set if duty cycle > or = 97%
        goto    setpwm  ; Duty cycle less than 97%
        movlw   MAXPWM  ; Limit duty cycle to 97%
        movwf   PWMLO
        goto    setpwm
;
;*******************************************************************
;       COUNT > Max Limit - Adjust PWM up by INTFACT to decrease amplitude
;
ovrmax  movf    PWMDN,F ; Test if last correction direction was down
        btfss   STATUS,Z ; Z bit set if not down
        clrf    INTFACT ; Last direction down, clear INTFACT before increment
        incf    INTFACT,F ; Increment INTFACT by 2
        incf    INTFACT,F
        bsf     PWMUP,0 ; Set PWMUP flag
        clrf    PWMDN   ; Clear PWMDN flag
        movf    INTFACT,W ; Add INTFACT to PWMLO
        addwf   PWMLO,F
        btfsc   STATUS,C ; C bit set on add overflow
        incf    PWMHI,F ; Increment duty cycle MSBs on overflow
        btfss   PWMHI,0 ; Test for duty cycle over 97%
        goto    incint  ; 2nd MSB clear, duty cycle cannot be over 97%
        btfss   PWMHI,1 ; Test for duty cycle over 97%
```

```
         goto    incint  ; MSB clear, duty cycle cannot be over 97%
         movlw   MAXPWM  ; Test PWMLO for duty cycle over 97%
         subwf   PWMLO,W
         btfss   STATUS,C ; C bit set if duty cycle > or = 97%
         goto    incint   ; Duty cycle less than 97%
         movlw   MAXPWM  ; Limit duty cycle to 97%
         movwf   PWMLO
;
;*******************************************************************
;        Adjust Integrator Value And Load New Duty Cycle
;
incint   incf    INTFACT,F ; Increment INTFACT
         movlw   MAXINT  ; Check INTFACT for limit condition
         subwf   INTFACT,W
         btfss   STATUS,C ; C bit set if INTFACT over (or equal to) max
         goto    setpwm  ; INTFACT not over max
         movlw   MAXINT  ; Limit INTFACT to max
         movwf   INTFACT
         bsf     UNCALFL,0 ; Set UNCAL flag if INTFACT is being limited
setpwm   rrf     PWMHI,W ; Shift PWMHI LSB into carry bit
         rrf     PWMLO,W ; Shift carry to PWMLO MSB with LSB shifted out
         movwf   TEMP    ; Move duty cycle value to tmp register for shift
         rrf     TEMP,W  ; Write value back in W w/2nd LSB shifted out
         andlw   PWMMASK ; Clear MSB of shifted PWMLO
         btfsc   PWMHI,1 ; Test 2nd MSB of duty cycle
         xorlw   PWMORM  ; Set MSB of shifted PWMLO if duty cycle MSB set
         bcf     CCP1CON,4 ; Clear PWM duty cycle LSB's
         bcf     CCP1CON,5
         btfsc   PWMLO,0 ; Test LSB of PWMLO
         bsf     CCP1CON,4 ; Set PWM duty cycle LSB
         btfsc   PWMLO,1 ; Test 2nd LSB of PWMLO
         bsf     CCP1CON,5 ; Set PWM duty cycle 2nd LSB
         movwf   CCPR1L  ; Load shifted PWMLO into PWM duty cycle register
pwmrtn   return
;
;*******************************************************************
;        Trigger Saw Brake Subroutine - Does Not Return
;
sawtrg   bsf     PORTC,TRIG ; Trigger saw brake
         bsf     PORTC,MOT ; Stop saw motor
         movlw   CHRGOFF ; Turn off capacitor charging
         movwf   XDATA
         movlw   ICONC   ; Set interrupts for UART and Timer 1 only
         movwf   INTCON
         movlw   DL100US ; Delay for 100uS to be sure SCR is latched
         movwf   TEMP
dllp1    decfsz  TEMP,F
         goto    dllp1
         movlw   TRISC   ; Set FSR to point to TRISC
         movwf   FSR
         movlw   PRTC2   ; Set Trigger output to HiZ
         movwf   INDF
         movlw   BITER4  ; Set BIT blinker to 8-0f-8
         movwf   BITBLO
         movwf   BITBHI
         goto    sdsaw   ; Complete saw shutown with LED blinking
;
;*******************************************************************
;        Shutdown Saw Subroutine - Does Not Return
;
shutdn   bsf     PORTC,MOT ; Stop saw motor
         movlw   CHRGOFF ; Turn off capacitor charging
         movwf   XDATA
         movlw   ICONC   ; Set interrupts for UART and Timer 1 only
         movwf   INTCON
sdsaw    clrf    ARMFL   ; Clear the armed flag
         bcf     CCP1CON,4 ; Reset PWM duty cycle to 70%
         bcf     CCP1CON,5
         movlw   PWMDC
         movwf   CCPR1L
         bcf     PORTC,GLED ; Turn off green LED
; Blink red LED according to pattern in BITBHI/LO, endless loop
         movlw   MS300PL ; Initialize 300mS software timer
         movwf   TMR500
dllp2    movf    PWMFL,F ; Dummy move to set Z status
         btfsc   STATUS,Z ; Z bit clear if PWMFL is set
         goto    dllp2   ; No 400µS timeout, continue wait loop
```

```
        clrf    PWMFL   ; 400µS timeout, clear flag
        decfsz  TMR100,F ; Dec 100mS timer, reload on 0
        goto    dllp2   ; No 100mS timeout, continue wait loop
        movlw   T100PL  ; 100mS timeout, reload 100mS tir
        movwf   TMR100
        decfsz  TMR500,F ; Dec. TMR500 and blink red LED ir 0
        goto    dllp2   ; No 500mS timeout, continue wait loop
; 300mS timeout, blink red LED
        rrf     BITBHI,F ; Shift LSB of BITLHI into C bit
        rrf     BITBLO,F ; Shift C into MSB of BITBLO, LSB into C bit
        btfsc   STATUS,C ; C is set if red LED should be on
        goto    setrled ;
        bcf     PORTC,RLED ; Turn off Red LED
        goto    setmsb  ; Set BITBHI MSB to equal former BITBLO LSB
setrled bsf     PORTC,RLED ; Turn on Red LED
; Set BITBHI MSB to previous BITBLO LSB value to complete loop shift
setmsb  bcf     BITBHI,7 ; Preclear BITBHI MSB
        btfsc   STATUS,C ; C bit still valid from shift instruction
        bsf     BITBHI,7 ; Sets MSB if former LSB was 1
        movlw   MS300PL ; Reinitialize 300mS software timer
        movwf   TMR500
        goto    dllp2
;
;*****************************************************************
;       Processor initialization
;
main    movlw   OPTREG  ; Load FSR to point to OPTION register
        movwf   FSR
        movlw   OPTVL   ; Initialize OPTION register
        movwf   INDF
        clrf    PORTA   ; Clear Ports before configuring outputs
        clrf    PORTB
        clrf    PORTC
        bsf     PORTC,MOT ; Set saw motor off
        movlw   TRISA   ; Set FSR to point to TRISA
        movwf   FSR
        movlw   PRTA    ; Initialize TRIS for PORTA
        movwf   INDF
        incf    FSR,F
        movlw   PRTB    ; Initialize TRIS for PORTB
        movwf   INDF
        incf    FSR,F
        movlw   PRTC    ; Initialize TRIS for PORTC
        movwf   INDF
;
;*****************************************************************
;       Initialize Flags and Variables
;
        clrf    TRIGFL  ; Clear all flags
        clrf    UNCALFL
        clrf    CHRGFL
        clrf    TMRFL
        clrf    SMRUN
        clrf    SMBPS
        clrf    WTBPS
        clrf    WTSTP
        clrf    ARMFL
        clrf    PWMFL
        clrf    PWMUP
        clrf    PWMDN
        clrf    PARMFL
        clrf    PARMTO
        clrf    HSENSE  ; Initialize Hall sensor flag
        bsf     HSENSE,0
        clrf    INTFACT ; Initialize variable INTFACT
        movlw   T100PL  ; Initialize 100mS Software Timer
        movwf   TMR100
        movlw   CHRGON  ; Initialize variable XDATA for cap charging
        movwf   XDATA
        clrf    PWMHI   ; Initialize PWM duty cycle variables to 70%
        bsf     PWMHI,1
        movlw   PWMLOPL
        movwf   PWMLO
        movlw   MAXTIME ; Initialize min discharge time register
        movwf   MTREG
        movlw   BITER5  ; Initialize BIT error blinker - solid red
        movwf   BITBLO
```

```
        movwf   BITBHI
;
;*******************************************************************
;       Initialize Timer
;
        movlw   T1HIGH  ; Initialize Timer 1 high byte
        movwf   TMR1H
        movlw   T1LOW   ; Initialize Timer 1 low byte
        movwf   TMR1L
        movlw   TMR1CON ; Configure Timer 1 and start
        movwf   T1CON
;
;*******************************************************************
;       Initialize PWM
;
        movlw   PR2     ; Load FSR to point to PR2 register
        movwf   FSR
        movlw   PWMPER  ; Initialize PWM period
        movwf   INDF
        movlw   PWMDC   ; Initialize PWM duty cycle
        movwf   CCPR1L
        movlw   TMR2CON ; Initialize and start Timer 2
        movwf   T2CON
        movlw   PWM1CON ; Initialize CCP1 for PWM mode
        movwf   CCP1CON
;
;*******************************************************************
;       Initialize UART
;
        movlw   SPBRG   ; Load FSR to point to Baud Rate register
        movwf   FSR
        movlw   BAUDRG  ; Initialize Baud Rate
        movwf   INDF
        movlw   TXSTA   ; Load FSR to point to TX con. register
        movwf   FSR
        movlw   UARTTX  ; Initialize TX con. register
        movwf   INDF
        movlw   UARTRX  ; Initialize RX con. register
        movwf   RCSTA
        movf    XDATA,W ; Load first data byte
        movwf   TXREG
;
;*******************************************************************
;       Set Interrupt Enables
;
        movlw   PIE1    ; Load FSR to point to PIE1 register
        movwf   FSR
        movlw   PIE1LD  ; Initialize PIE1 register
        movwf   INDF
        movlw   ICONA   ; Initialize INTCON register
        movwf   INTCON
;
;*******************************************************************
;       Initial System Self-Test
;
        bsf     PORTC,RLED ; Turn on the red LED
;
;*******************************************************************
;       Wait Until Supplies Are Stable
;       Waits two seconds for supplies to stabilize.  Shuts saw
;       down if supplies are under voltage
;
        movlw   S2PL    ; Setup 2 second timer
        movwf   STMRC
vtstlp1 btfss   PORTB,LVOLT ; Test Low Voltage sense bit
        goto    itcc    ; Sense bit clear, supplies in regulation
        movf    TMRFL,F ; Dummy move to set Z status
        btfsc   STATUS,Z ; Z bit set if TMRFL is clear
        goto    vtsk1   ; TMRFL not set, check overvoltage
        clrf    TMRFL   ; Flag set, clear flag and dec. counter
        decfsz  STMRC,F ; TMRFL set, dec. STMRC and shutdown if 0
        goto    vtsk1   ; 2 S not up, check overvoltage
        movlw   BITER4  ; Supplies not regulated, set BIT blinker to 7-of-8
        movwf   BITBLO
        movlw   BITER3
        movwf   BITBHI
        call    shutdn  ; Shut saw down
```

```
vtskl   btfsc   PORTA,OVRVLT ; OVRVLT is high if link is blown
        goto    blnlnk
        movf    PWMFL,F ; Dummy move to set Z status
        btfss   STATUS,Z ; Z bit set if PWMFL is clear
        call    adjpwm  ; Set PWM duty cycle to maintain calibration
        goto    vtstlpl ; Loop back for another pass
;
;*****************************************************************
;       Initial Trigger Capacitor Charge - Within 10 Seconds
;
itcc    movlw   S10PL   ; Setup 10 second timer
        movwf   STMRC
chglp1  btfss   PORTA,THRESH ; THRESH high if cap under voltage
        goto    dischgl ; Threshold reached, test discahrge
        movf    TMRFL,F ; Dummy move to set Z status
        btfsc   STATUS,Z ; Z bit set if TMRFL is clear
        goto    clskl   ; TMRFL not set, check overvoltage
        clrf    TMRFL   ; Flag set, clear flag and dec. counter
        decfsz  STMRC,F ; TMRFL set, dec. STMRC and shutdown if 0
        goto    clskl   ; 10 S not up, check overvoltage
        movlw   BITER4  ; Cap did not charge, set BIT blinker to 4-of-8
        movwf   BITBLO
        clrf    BITBHI
        call    shutdn  ; Shut saw down
clskl   btfsc   PORTA,OVRVLT ; OVRVLT is high if link is blown
        goto    blnlnk
        movf    PWMFL,F ; Dummy move to set Z status
        btfss   STATUS,Z ; Z bit set if PWMFL is clear
        call    adjpwm  ; Set PWM duty cycle to maintain calibration
        goto    chglp1  ; Loop back for another pass
blnlnk  movlw   BITER4  ; Overvoltage, link blown??, set BIT blinker to 6-of-8
        movwf   BITBLO
        movlw   BITER2
        movwf   BITBHI
        call    shutdn  ; Shut saw down
;
;*****************************************************************
;       Initial Trigger Capacitor Discharge - Discharge < 5
;
dischgl movlw   S5PL    ; Setup 5 second timer
        movwf   STMRB
dchglp1 btfsc   PORTA,THRESH ; THRESH low if cap at voltage
        goto    wtrest  ; Threshold reached, wait for 5 S timeout
        movf    TMRFL,F ; Dummy move to set Z status
        btfsc   STATUS,Z ; Z bit set if TMRFL is clear
        goto    dclskl  ; TMRFL not set, check overvoltage (comp. fail)
        clrf    TMRFL   ; Flag set, clear flag and dec. counter
        decfsz  STMRB,F ; TMRFL set, dec. STMRB and shutdown if 0
        goto    dclskl  ; 5 S not up, check overvoltage (comp. fail)
        movlw   BITER3  ; Cap did not discharge, set BIT blinker to 3-of-8
        movwf   BITBLO
        clrf    BITBHI
        call    shutdn  ; Shut saw down
dclskl  btfsc   PORTA,OVRVLT ; OVRVLT is high if link is blown
        goto    blnlnk
        movf    PWMFL,F ; Dummy move to set Z status
        btfss   STATUS,Z ; Z bit set if PWMFL is clear
        call    adjpwm  ; Set PWM duty cycle to maintain calibration
        goto    dchglpl ; Loop back for another pass
wtrest  movf    TMRFL,F ; Dummy move to set Z status
        btfsc   STATUS,Z ; Z bit set if TMRFL is clear
        goto    dclsk2  ; TMRFL not set, check overvoltage (comp. fail)
        clrf    TMRFL   ; Flag set, clear flag and dec. counter
        decfsz  STMRB,F ; TMRFL set, dec. STMRB and continue self-test if 0
        goto    dclsk2  ; 5 S not up, check overvoltage (comp. fail)
        goto    chkcal  ; Continue self-test with calibration check
dclsk2  btfsc   PORTA,OVRVLT ; OVRVLT is high if link is blown
        goto    blnlnk
        movf    PWMFL,F ; Dummy move to set Z status
        btfss   STATUS,Z ; Z bit set if PWMFL is clear
        call    adjpwm  ; Set PWM duty cycle to maintain calibration
        goto    wtrest  ; Loop back for another pass
;
;*****************************************************************
;       Check In Calibration Flag
;
chkcal  movf    UNCALFL,F ; Dummy move to set Z status
```

```
        btfsc   STATUS,Z ; Z bit 0 if sense circuit not in cal
        goto    chktrg  ; In calibration, check for trigger sense
        movlw   BITER2  ; Sense circuit not in cal, set BIT blinker to 2-of-8
        movwf   BITBLO
        clrf    BITBHI
        call    shutdn  ; Shut saw down
;
;*****************************************************************
;       Check For Active Trigger Sense Circuit
;
chktrg  movf    TRIGFL,F ; Dummy move to set Z status
        btfsc   STATUS,Z ; Z bit set if TRIGFL 0 (sense circuit active)
        goto    sawop   ; Enter saw operation loop, self test passed
        movlw   MS200PL ; Initialize 200mS software timer
        movwf   TMR200
ttstlpl movf    TRIGFL,F ; Dummy move to set Z status
        btfsc   STATUS,Z ; Z bit set if TRIGFL 0 (sense circuit active)
        goto    sawop   ; Enter saw operation loop, self test passed
        movf    TMRFL,F ; Dummy move to set Z status
        btfsc   STATUS,Z ; Z bit set if TMRFL is clear
        goto    ttstskl ; TMRFL not set, check overvoltage
        clrf    TMRFL   ; Flag set, clear flag and dec. counter
        decfsz  TMR200,F ; TMRFL set, dec. TMR200 and shutdown if 0
        goto    ttstskl ; 200mS not up, check overvoltage
        movlw   BITER1  ; No triggers from sense, set BIT blinker to 1-of-8
        movwf   BITBLO
        clrf    BITBHI
        call    shutdn  ; Shut saw down
ttstskl btfsc   PORTA,OVRVLT ; OVRVLT is high if link is blown
        goto    blnlnk
        movf    PWMFL,F ; Dummy move to set Z status
        btfss   STATUS,Z ; Z bit set if PWMFL is clear
        call    adjpwm  ; Set PWM duty cycle to maintain calibration
        goto    ttstlpl ; Loop back for another pass
;
;*****************************************************************
;       Saw Operational Loop
;       Loop begins with a simplified self-test that is repeated
;       in the loop.  Only the capacitor charge/discharge cycle is
;       monitored, which also tests the link.  If the trigger
;       circuit malfunctions, nothing will happen until the saw
;       is started, at which time the link will blow.  The loop
;       time is variable (according to mode) but is well under 20µS,
;       except when the adjpwm routine is called.
;
sawop   bcf     PORTC,RLED ; Self-test passed, turn off the red LED
        bsf     PORTC,GLED ; Turn on the green LED
        movlw   S5PL    ; Setup 5 second timer, wait for charge cycle
        movwf   STMRC
        bsf     CHRGFL,0 ; Set charge cycle flag
oploop  movf    PWMFL,F ; Dummy move to set Z status
        btfss   STATUS,Z ; Z bit set if PWMFL is clear
        call    adjpwm  ; Set PWM duty cycle to maintain calibration
        btfss   PORTB,LVOLT ; Test low voltage sense, skip self-test if set
        goto    runstst
        movlw   MAXTIME ; Low voltage, reset min discharge time register
        movwf   MTREG
        goto    blt     ; Check for overvoltage on cap (still works OK)
runstst movf    CHRGFL,F ; Dummy move to set Z status
        btfsc   STATUS,Z ; Z bit set for discahrge cycle
        goto    tstdchg ; Goto discharge cycle processing
;
;*****************************************************************
;       Charge Cycle Self-Test
;
        btfss   PORTA,THRESH ; THRESH high if cap under voltage
        goto    dchgpr  ; Threshold reached, setup for discahrge test
        movf    TMRFL,F ; Dummy move to set Z status
        btfsc   STATUS,Z ; Z bit set if TMRFL is clear
        goto    blt     ; TMRFL not set, check for overvoltage
        decfsz  STMRC,F ; TMRFL set, dec. STMRC and shutdown if 0
        goto    blt     ; 2 (5) S not up, check for overvoltage
        movlw   BITER4  ; Cap did not charge, set BIT blinker to 4-of-8
        movwf   BITBLO
        clrf    BITBHI
        call    shutdn  ; Shut saw down
dchgpr  clrf    CHRGFL  ; Set charge cycle flag to discharge
```

```
        movlw   S5PL    ; Setup 5 second timer
        movwf   STMRB
        goto    oplpa   ; Continue Op Loop
;
;*******************************************************************
;       Discharge Cycle Self-Test
;
tstdchg btfsc   PORTA,THRESH ; THRESH low if cap at voltage
        goto    mintm2  ; Threshold reached, test min. time
        movf    TMRFL,F ; Dummy move to set Z status
        btfsc   STATUS,Z ; Z bit set if TMRFL is clear
        goto    blt     ; TMRFL not set, check for overvoltage (comp. fail)
        decfsz  STMRB,F ; TMRFL set, dec. STMRB and shutdown if 0
        goto    blt     ; 5 S not up, check for overvoltage (comp. fail)
        movlw   BITER3  ; Cap did not discharge, set BIT blinker to 3-of-8
        movwf   BITBLO
        clrf    BITBHI
        call    shutdn  ; Shut saw down
mintm2  movf    MTREG,W ; Load W with min. discharge time value
        subwf   STMRB,W ; Subtract min. time from current timer value
        btfss   STATUS,C ; C bit 1 if timer value > or = min. time
        goto    setchrg ; Discharge OK, set up for charge cycle
        movlw   BITER3  ; Cap discharged too fast, set BIT blinker to 3-of-8
        movwf   BITBLO
        clrf    BITBHI
        call    shutdn  ; Shut saw down
setchrg movlw   MINTIME ; Test if MTREG value is greater than MINTIME
        subwf   MTREG,W
        btfsc   STATUS,C ; C bit 1 if MTREG value > or = MINTIME
        decf    MTREG,F ; MTREG not at min, decrement
        movlw   S2PL    ; Setup 2 second timer
        movwf   STMRC
        bsf     CHRGFL,0 ; Set charge cycle flag
;
;*******************************************************************
;       Blown Link Test
;
blt     btfss   PORTA,OVRVLT ; OVRVLT is high if link is blown
        goto    oplpa
        movlw   BITER4  ; Overvoltage, link blown??, set BIT blinker to 6-of-8
        movwf   BITBLO
        movlw   BITER2
        movwf   BITBHI
        call    shutdn  ; Shut saw down
;
;*******************************************************************
;       Self-Test Complete - Operational Code Begins
;
oplpa   btfss   PORTA,SWOFF ; Test stop switch
        goto    stopop  ; Process stop switch depression
rdsw1   btfss   PORTA,SWON ; Test start switch
        goto    strtop  ; Process start switch depression
rdsw2   btfss   PORTA,SWBPS ; Test bypass switch
        goto    bpswt   ; Process bypass switch depression
;
;*******************************************************************
;       Set Armed Flag
;       The Armed Flag is set only if the supplies are in regulation,
;       and not before 100mS after the Start switch was pressed.
;       An interval of 100mS is allowed to pass before the Low Voltage
;       Sense bit is tested.  It the sense bit is high, a wait of up to
;       two seconds is allowed before the Armed Flag is set.  This is
;       to allow the saw motor to come up to speed.  The start current
;       drawn by the saw motor can cause the internal supplies to drop
;       out of regulation if the AC supply to the saw is weak.  If the
;       voltages are not in regulation within two seconds, the saw is
;       shut down.  The Armed Flag is reset any time the Low Voltage
;       Sense bit is high after saw operation has begun.  A total of
;       two seconds of such operation is allowed during any one run
;       period before the saw is shut down.  This is to prevent the
;       saw from being used in marginal AC supply situations where
;       the internal supplies are dropping in and out of regulation.
;       Such circumstances may occur if the AC supply is weak and the
;       saw is being used under heavy load or if another tool on the
;       same weak circuit is started and causes the line voltage to
;       drop.
paproc  movf    PARMFL,F ; Dummy move to set Z status
```

```
        btfsc   STATUS,Z ; Z bit clear if if preliminary armed flag set
        goto    oplpb   ; Preliminary armed flag not set, continue Op Loop
        movf    PARMTO,F ; Dummy move to set Z status
        btfss   STATUS,Z [illegible] Z bit clear if initial timeout [illegible]s passed
        goto    tstlvs [illegible]nitial timeout passed, check [illegible] voltage sense
        movf    TMRFL,F ; Dummy move to set Z status
        btfsc   STATUS,Z ; Z bit set if TMRFL is clear
        goto    oplpb   ; Initial 100mS wait not over, continue Op Loop
        bsf     PARMTO,0 ; 100mS has passed, set initial timeout flag
tstlvs  btfss   PORTB,LVOLT ; Test Low Voltage Sense input
        goto    starfl  ; Supplies in regulation, set armed flag
        clrf    ARMFL   ; Low voltage, clear armed flag
        movf    TMRFL,F ; Dummy move to set Z status
        btfsc   STATUS,Z ; Z bit set if TMRFL is clear
        goto    oplpb   ; No 100mS timer flag, continue Op Loop
        decfsz  LVTMR,F ; 100mS flag set, dec. 2 second timer, shut down on 0
        goto    oplpb   ; 2 seconds not up, continue Op Loop
        movlw   BITER4  ; 2 seconds of low voltage passed, set BIT blinker to 7-of-8
        movwf   BITBLO
        movlw   BITER3
        movwf   BITBHI
        call    shutdn  ; Shut saw down
starfl  bsf     ARMFL,0 ; Everything OK, set armed flag (already set or not)
;
;*******************************************************************
;       Blink Green LED In Bypass Operation
;
oplpb   movf    SMBPS,F ; Dummy move to set Z status
        btfss   STATUS,Z ; Z bit clear if bypass operation
        goto    blskl   ; Bypass mode, blink LED
        movf    WTBPS,F ; Test for bypass wait mode
        btfsc   STATUS,Z ; Z bit clear if in wait for bypass mode
        goto    oplpc   ; Not in wait for bypass mode, continue Op Loop
blskl   movf    TMRFL,F ; Dummy move to set Z status
        btfsc   STATUS,Z ; Z bit set if TMRFL is clear
        goto    oplpc   ; TMRFL not set, continue Op Loop
        decfsz  TMR500,F ; TMRFL set, dec. TMR500 and toggle LED if 0
        goto    oplpc   ; 500mS not up, continue Op Loop
        btfss   PORTC,GLED ; Bit is set if Green LED is on
        goto    setgled ; Not on, turn on
        bcf     PORTC,GLED ; On, turn off
        goto    tmrini  ; Reinitialize 500mS timer
setgled bsf     PORTC,GLED ; Turn on Green LED
tmrini  movlw   MS500PL ; Reinitialize 500mS software timer
        movwf   TMR500
;
;*******************************************************************
;       Wait For Blade To Stop
;
oplpc   movf    WTSTP,F ; Dummy move to set Z status
        btfsc   STATUS,Z ; Z bit clear if wait mode for blade stop
        goto    oplpd   ; Continue Op Loop
        movf    TMRFL,F ; Dummy move to set Z status
        btfsc   STATUS,Z ; Z bit set if TMRFL is clear
        goto    oplpd   ; TMRFL not set, continue Op Loop
        decfsz  STMRA,F ; TMRFL set, dec. STMRA and clear flags if 0
        goto    oplpd   ; 1 S not up, continue Op Loop
        clrf    WTSTP   ; 1 S timed out, clear blade stop wait flag
        clrf    SMBPS   ; Clear bypass mode flag
        clrf    ARMFL   ; Clear armed flag
        clrf    PARMFL  ; Clear preliminary armed flag
        clrf    PARMTO  ; Clear arming initial timeout flag
        clrf    SMRUN   ; Clear run flag
        bsf     PORTC,GLED ; Green LED may have blinked off, turn on
        movlw   ICONA   ; Disable Hall sensor interrupt
        movwf   INTCON
        movf    HSENSE,F ; Dummy move to check Hall sensor flag
        btfsc   STATUS,Z ; Z bit set if Hall sensor was active
        goto    oplpd   ; Hall sensor OK, continue Op Loop
        movlw   BITER4  ; Hall sensor defective, set BIT blinker to 5-of-8
        movwf   BITBLO
        movlw   BITER1
        movwf   BITBHI
;       call    shutdn  ; Shut saw down
;
;*******************************************************************
;       Wait After Bypass Switch Depression
```

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```
;         Wait mode persists for 2 seconds after Bypass Switch
;         depression
;
oplpd     movf    WTBPS,F ; Dummy move to set Z status
          btfsc   STATUS,Z ; Z bit clear if in wait for bypass mode
          goto    oplpe   ; Continue Op Loop
          movf    TMRFL,F ; Dummy move to set Z status
          btfsc   STATUS,Z ; Z bit set if TMRFL is clear
          goto    oplpe   ; TMRFL not set, continue Op Loop
          decfsz  STMRA,F ; TMRFL set, dec. STMRA and clear WTBPS if 0
          goto    oplpe   ; 2 S not up, continue Op Loop
          clrf    WTBPS   ; Clear wait for bypass
          bsf     PORTC,GLED ; Green LED may have blinked off, turn on
;
;*****************************************************************
;         End of Op Loop
;
oplpe     clrf    TMRFL   ; Clear TMR100 flag
          goto    oploop
;
;*****************************************************************
;         Stop Switch Processing
;
stopop    movf    SMRUN,F ; Dummy move to set Z status
          btfsc   STATUS,Z ; Z bit clear if in run mode
          goto    stpskl  ; Not running, cancel wait in bypass mode
          movf    WTSTP,F ; Dummy move to set Z status
          btfss   STATUS,Z ; Z bit clear if stop switch already read
          goto    rdsw1   ; Already read, check remaining switches
          bsf     PORTC,MOT ; Stop op processing, turn off motor
          bsf     WTSTP,0 ; Set WTSTP flag
          movlw   S1PL    ; Load Software Timer A for 1 second period
          movwf   STMRA
          movlw   ICONB   ; Enable Hall sensor interrupt
          movwf   INTCON
          bsf     HSENSE,0 ; Set Hall sensor flag
          goto    rdsw1   ; Check remaining switches
; May not be in wait in bypass mode, but clear it just in case
stpskl    clrf    WTBPS   ; Clear wait in bypass mode flag
          bsf     PORTC,GLED ; Green LED may have blinked off, turn on
          goto    rdsw1   ; Check remaining switches
;
;*****************************************************************
;         Start Switch Processing
;
strtop    movf    SMRUN,F ; Dummy move to set Z status
          btfss   STATUS,Z ; Z bit clear if in run mode
          goto    rdsw2   ; Already running, check remaining switch
          movf    WTBPS,F ; Dummy move to set Z status
          btfsc   STATUS,Z ; Z bit clear in bypass wait mode
          goto    strnmd  ; Not in bypass wait mode, start arm processing
          clrf    WTBPS   ; In bypass wait mode, clear WTBPS flag
          bsf     SMBPS,0 ; Set run in bypass mode flag
          goto    stskl
strnmd    bsf     PARMFL,0 ; Set preliminary armed flag
          movlw   S2PL    ; Setup 2 second low voltage timer
          movwf   LVTMR
          movlw   T100PL  ; Reset 100mS timer to start new period
          movwf   TMR100
          clrf    TMRFL   ; Clear TMR100 flag
stskl     bsf     SMRUN,0 ; Set run flag
          bcf     PORTC,MOT ; Turn motor on
          goto    rdsw2   ; Check remaining switch
;
;*****************************************************************
;         Bypass Switch Processing
;
bpswt     movf    SMRUN,F ; Dummy move to set Z status
          btfss   STATUS,Z ; Z bit clear if in run mode
          goto    paproc  ; Already running, continue Op Loop
          movf    WTBPS,F ; Dummy move to set Z status
          btfss   STATUS,Z ; Z bit clear in bypass wait mode
          goto    paproc  ; Already in bypass wait mode, continue Op Loop
          bsf     WTBPS,0 ; Set WTBPS flag
          movlw   S2PL    ; Load Software Timer A for 2 second period
          movwf   STMRA
          movlw   MS500PL ; Initialize 500mS software timer
```

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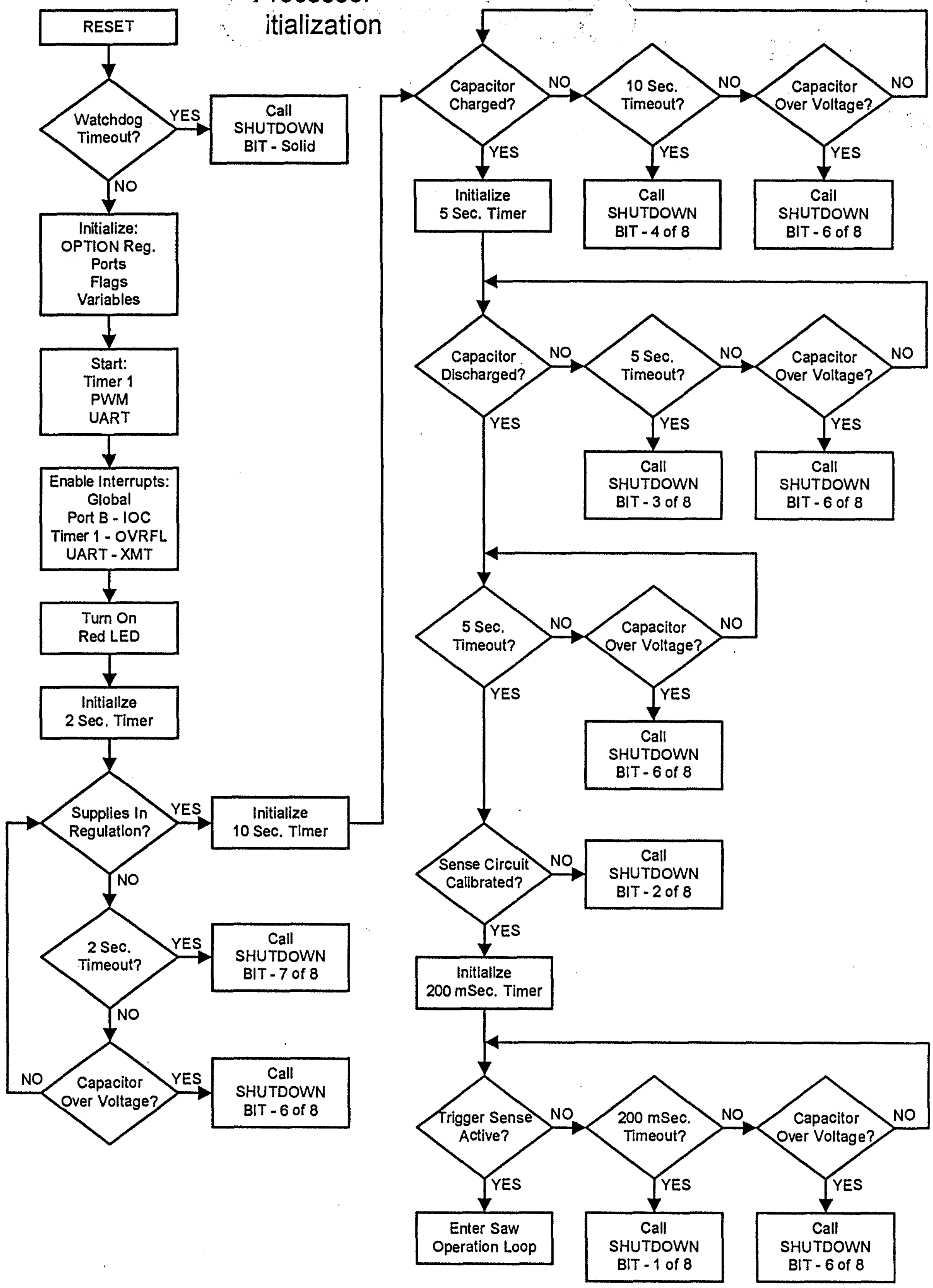
```
        movwf   TMR500
        bcf     PORTC,GLED ; Turn off the green LED
        goto    paproc ; Continue Op Loop
;
        end
```

Processor itialization



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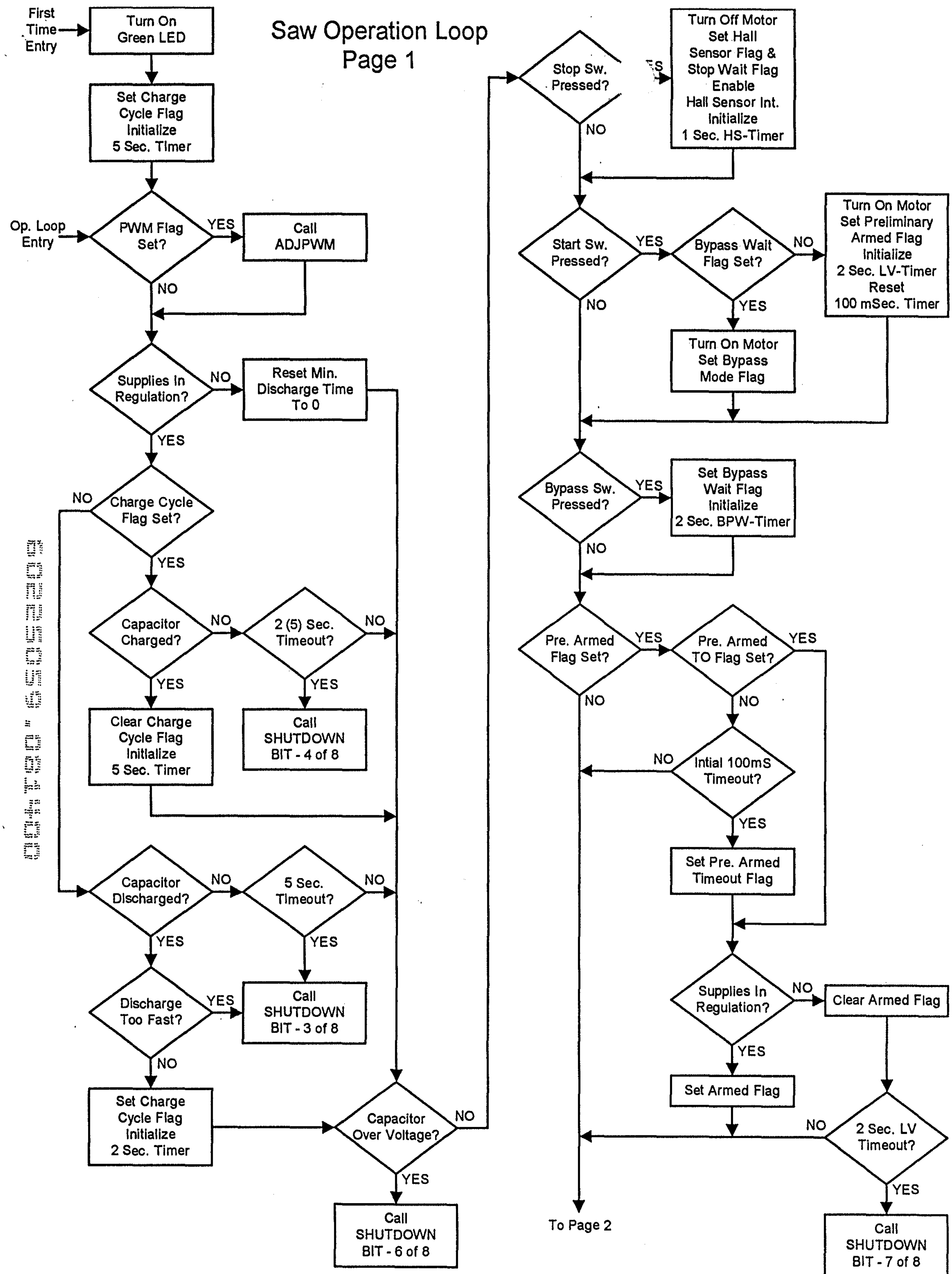
Saw Operation Loop Page 1



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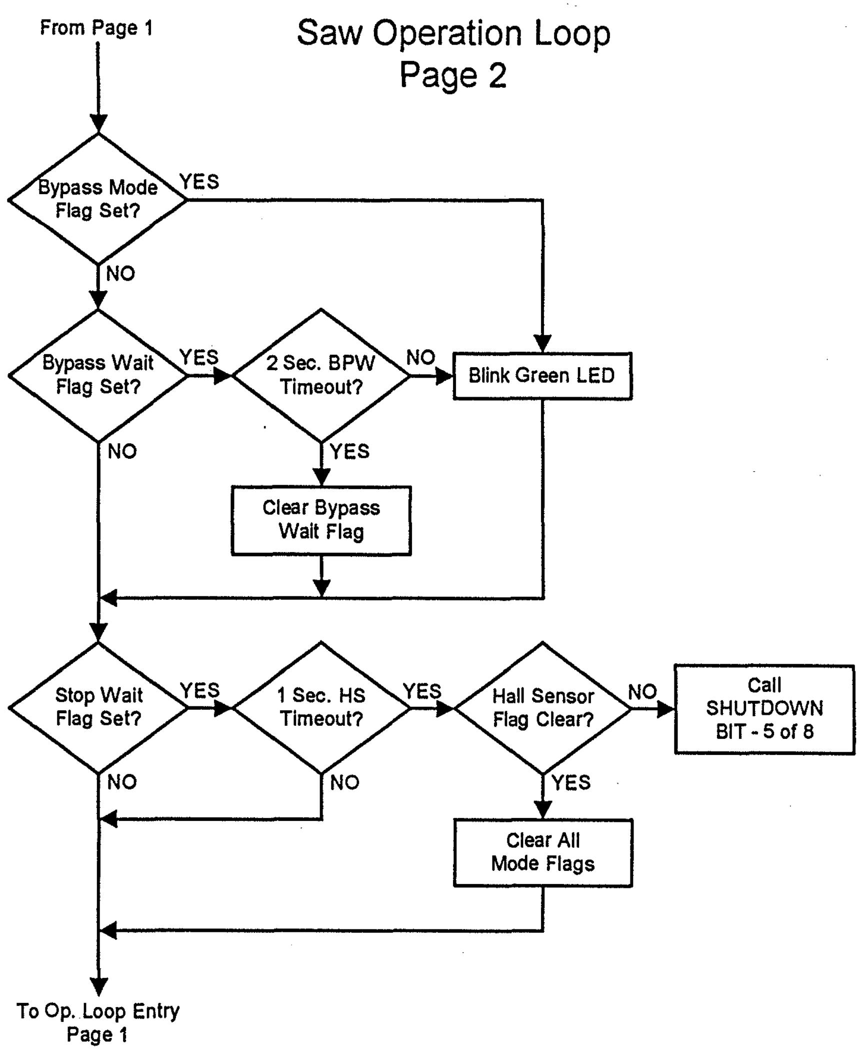

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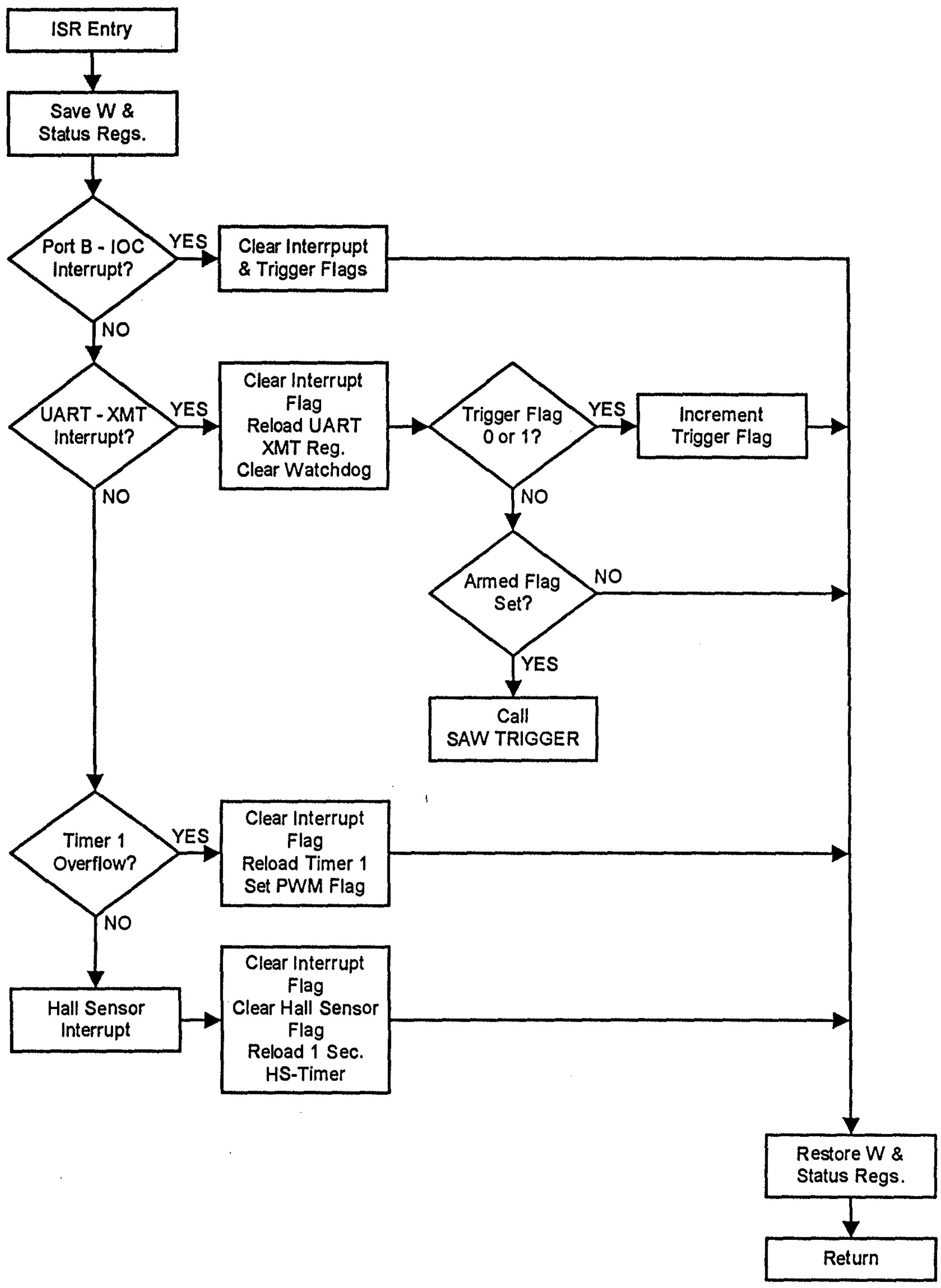
Interrupt Service Routine



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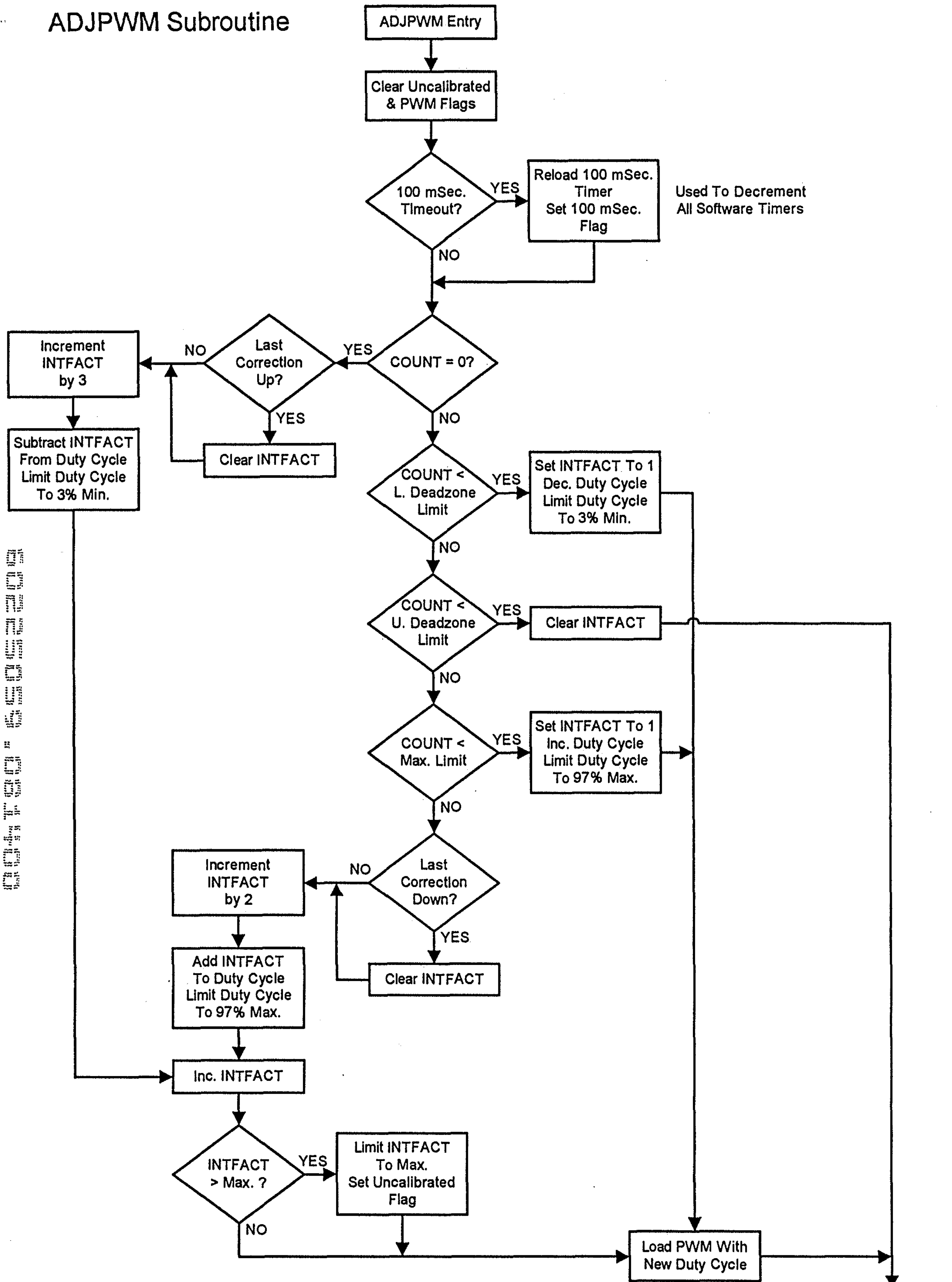
ADJPWM Subroutine



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SAW TRIGGER & SHUTDOWN Subroutines

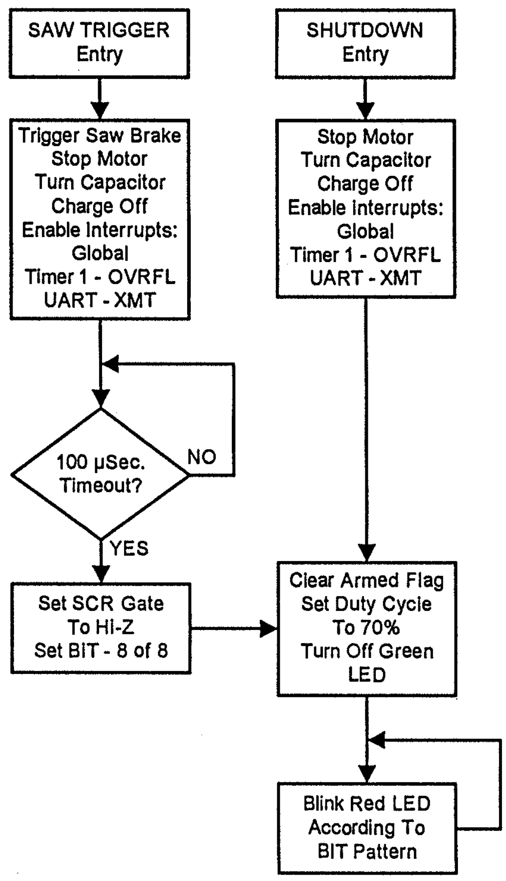


Fig. 1

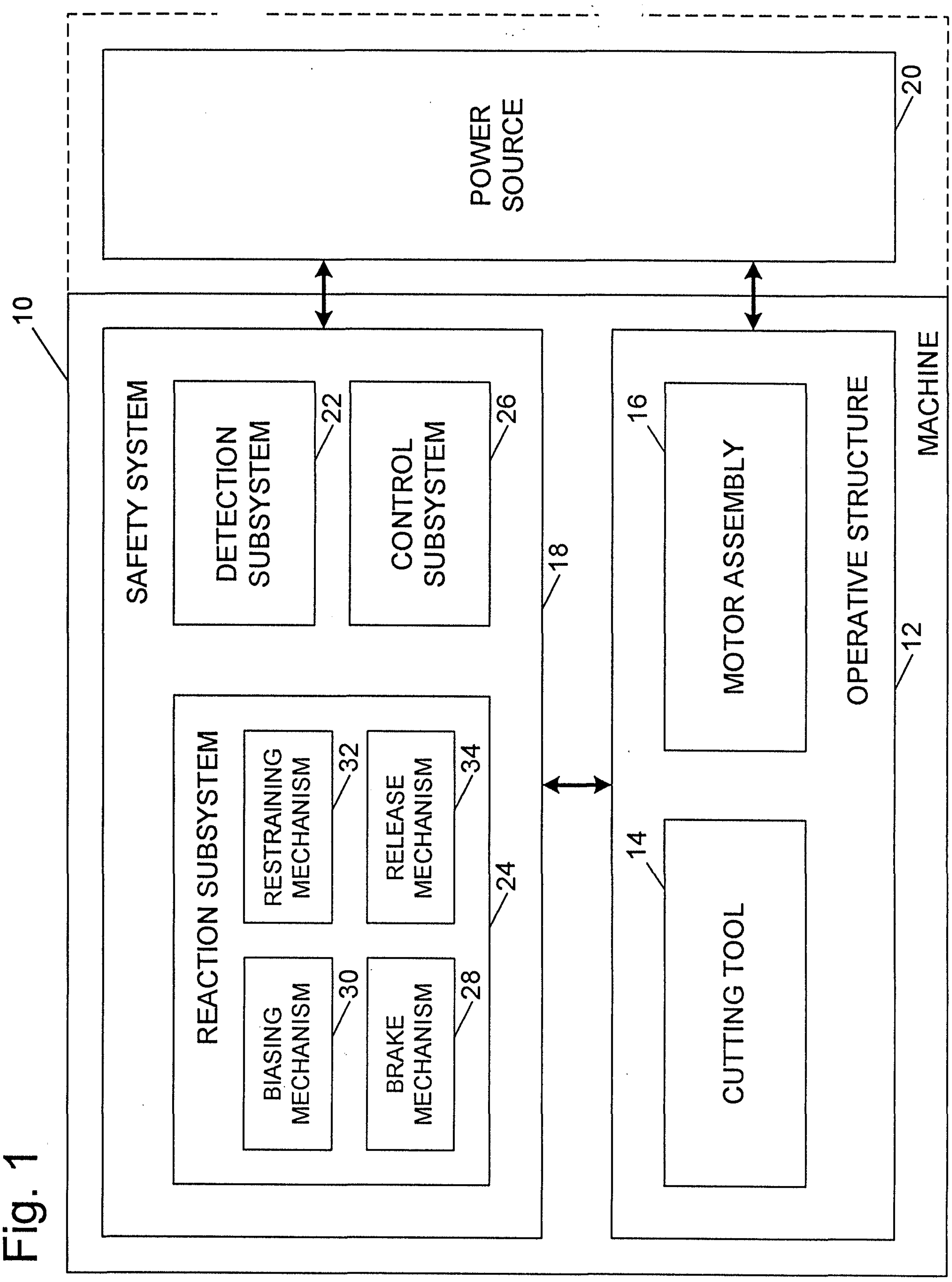

10
POWER SOURCE
20
SAFETY SYSTEM
DETECTION SUBSYSTEM
22
CONTROL SUBSYSTEM
26
18
REACTION SUBSYSTEM
RESTRAINING MECHANISM
32
RELEASE MECHANISM
34
BIASING MECHANISM
30
BRAKE MECHANISM
28
24
MOTOR ASSEMBLY
16
CUTTING TOOL
14
OPERATIVE STRUCTURE
12
MACHINE

Fig. 2

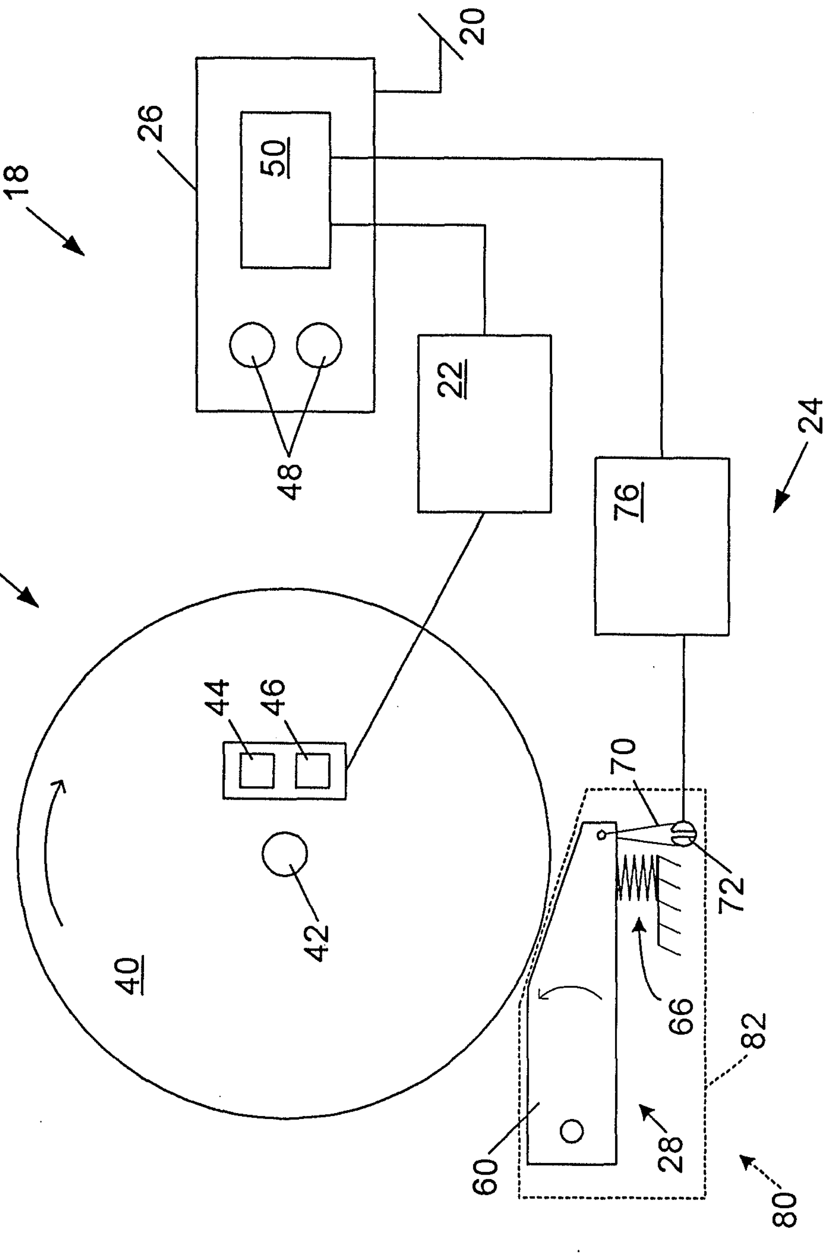
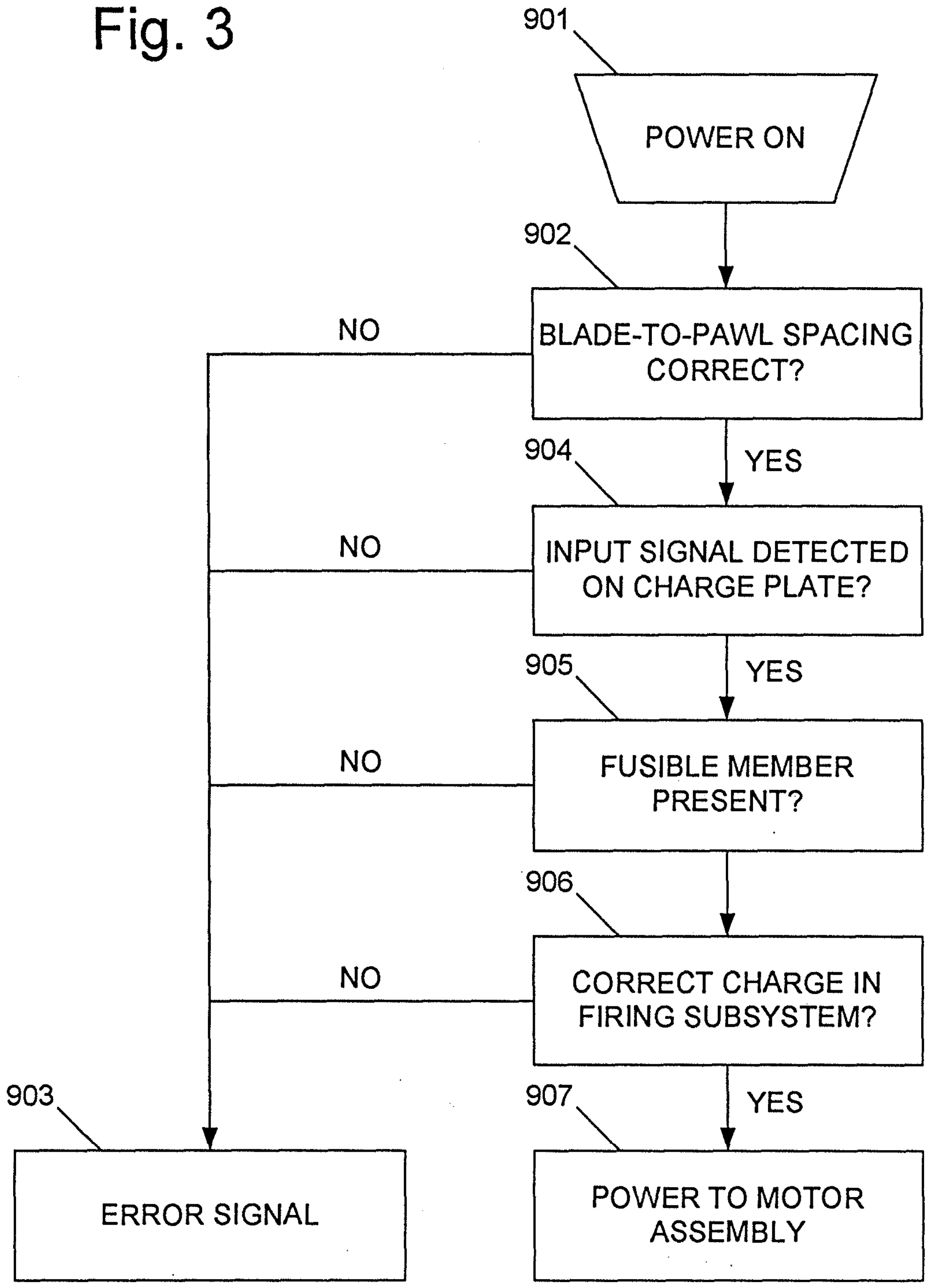


Fig. 3


901
POWER ON
902
BLADE-TO-PAWL SPACING CORRECT?
NO
YES
904
INPUT SIGNAL DETECTED ON CHARGE PLATE?
NO
YES
905
FUSIBLE MEMBER PRESENT?
NO
906
CORRECT CHARGE IN FIRING SUBSYSTEM?
NO
YES
903
ERROR SIGNAL
907
POWER TO MOTOR ASSEMBLY

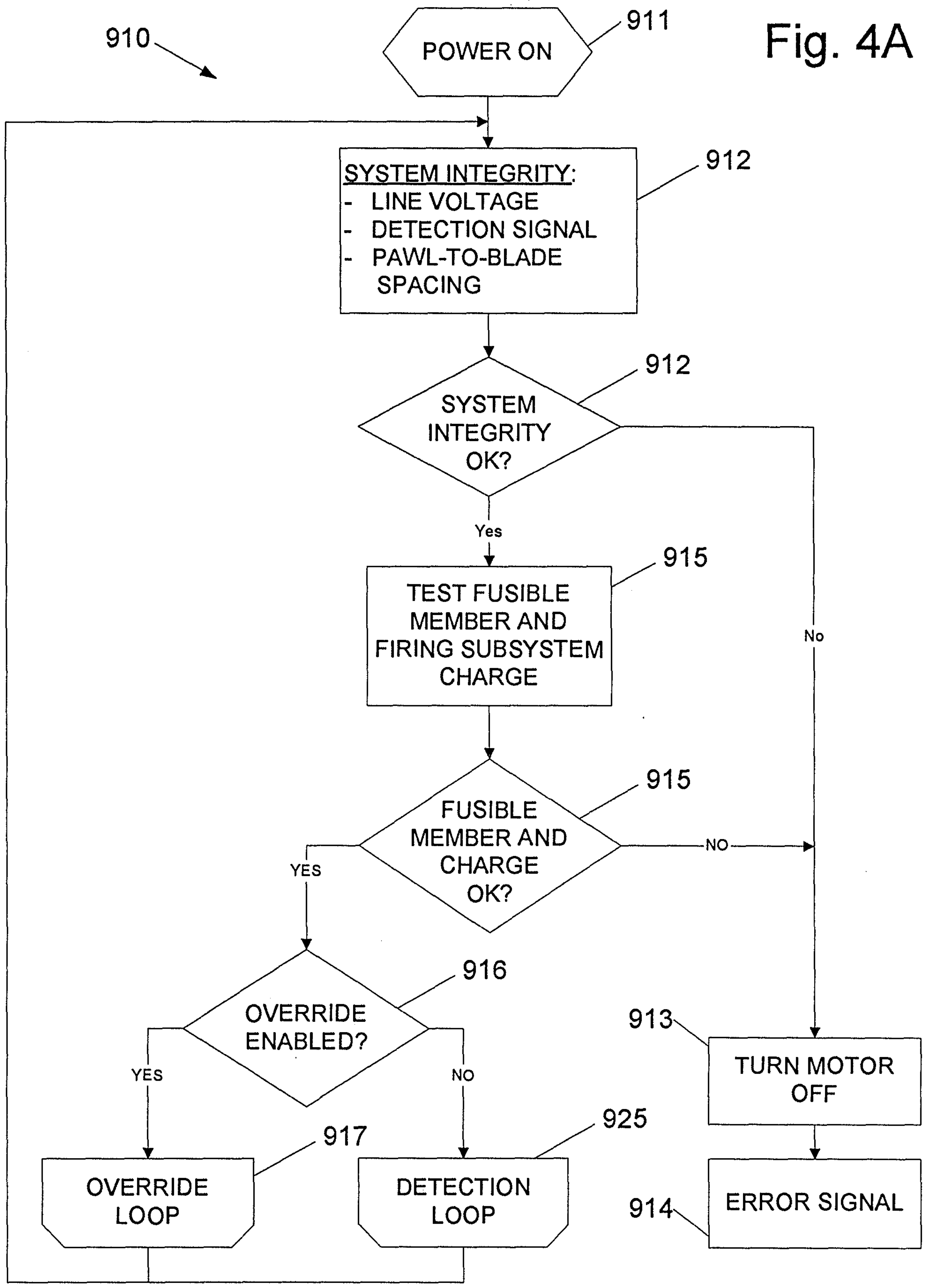
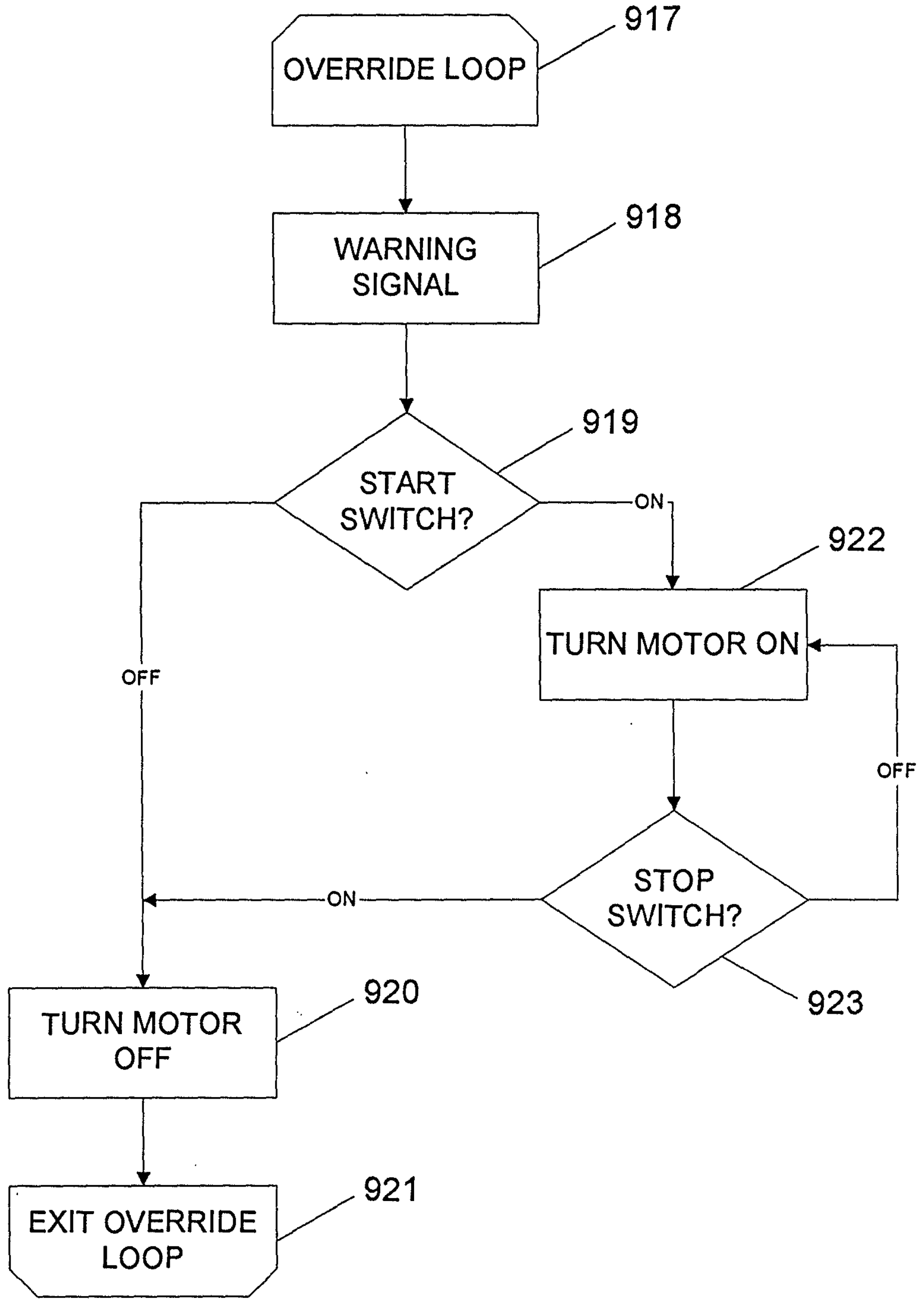

910
POWER ON
911
SYSTEM INTEGRITY:
- LINE VOLTAGE
- DETECTION SIGNAL
- PAWL-TO-BLADE SPACING
912
SYSTEM INTEGRITY OK?
912
Yes
No
TEST FUSIBLE MEMBER AND FIRING SUBSYSTEM CHARGE
915
FUSIBLE MEMBER AND CHARGE OK?
915
YES
NO
OVERRIDE ENABLED?
916
YES
NO
913
TURN MOTOR OFF
OVERRIDE LOOP
917
DETECTION LOOP
925
914
ERROR SIGNAL

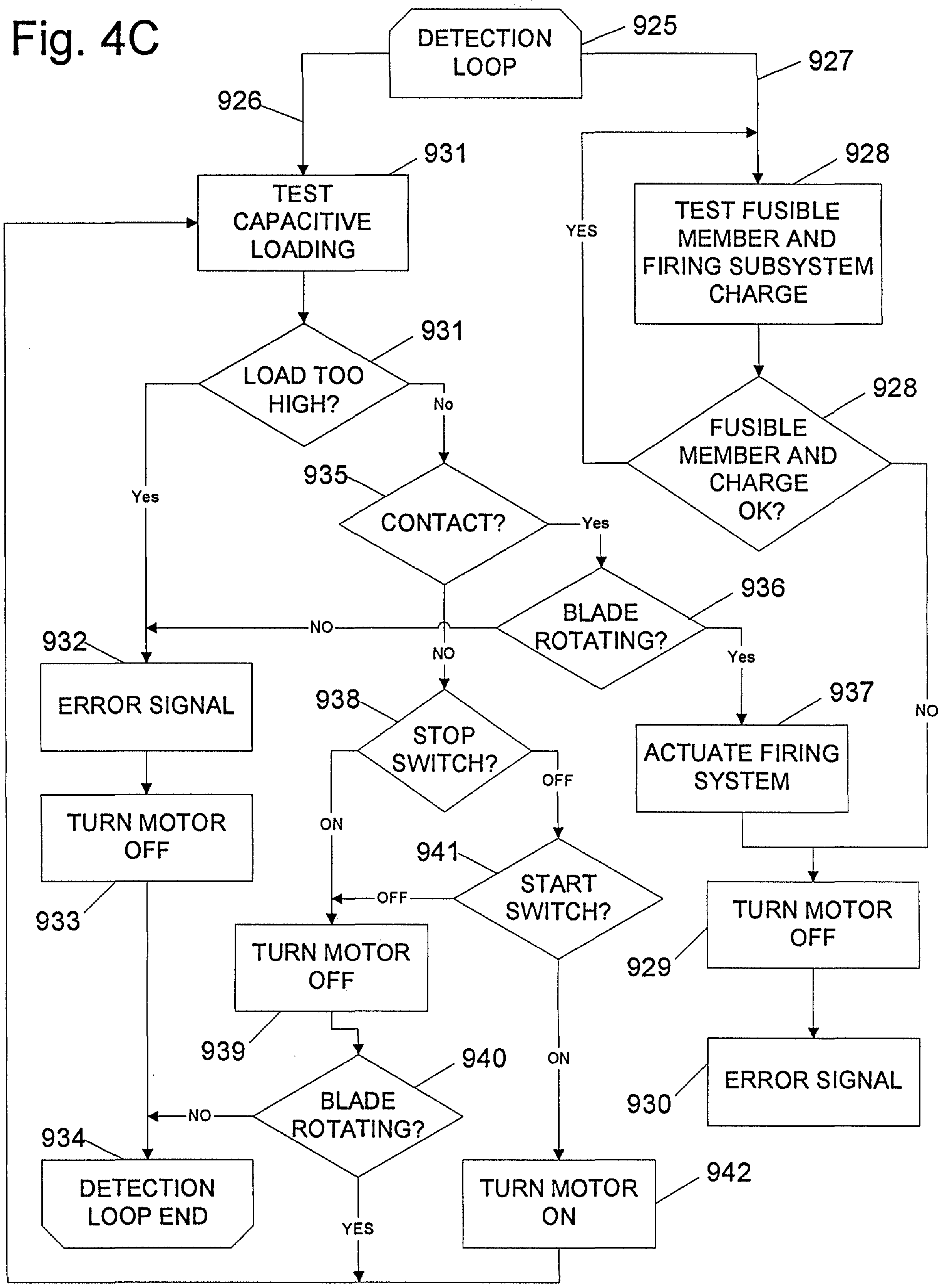
Fig. 4A

Fig. 4B



00471001 . 050309

Fig. 4C



00479059 . 052303

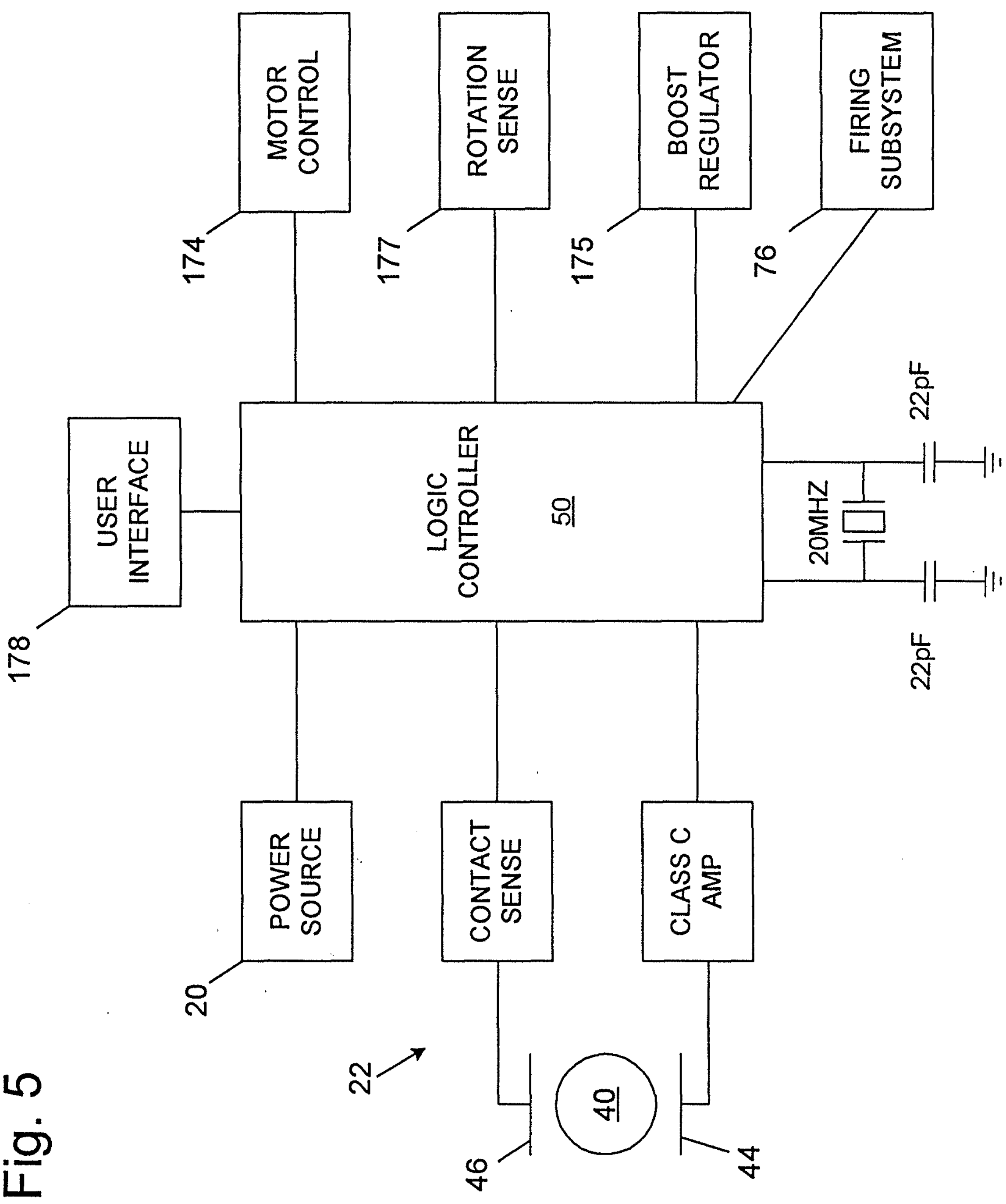

MOTOR CONTROL
ROTATION SENSE
BOOST REGULATOR
FIRING SUBSYSTEM
174
177
175
76
USER INTERFACE
178
LOGIC CONTROLLER
50
20MHZ
22pF
22pF
POWER SOURCE
CONTACT SENSE
CLASS C AMP
20
22
40
46
44

Fig. 5

Fig. 6

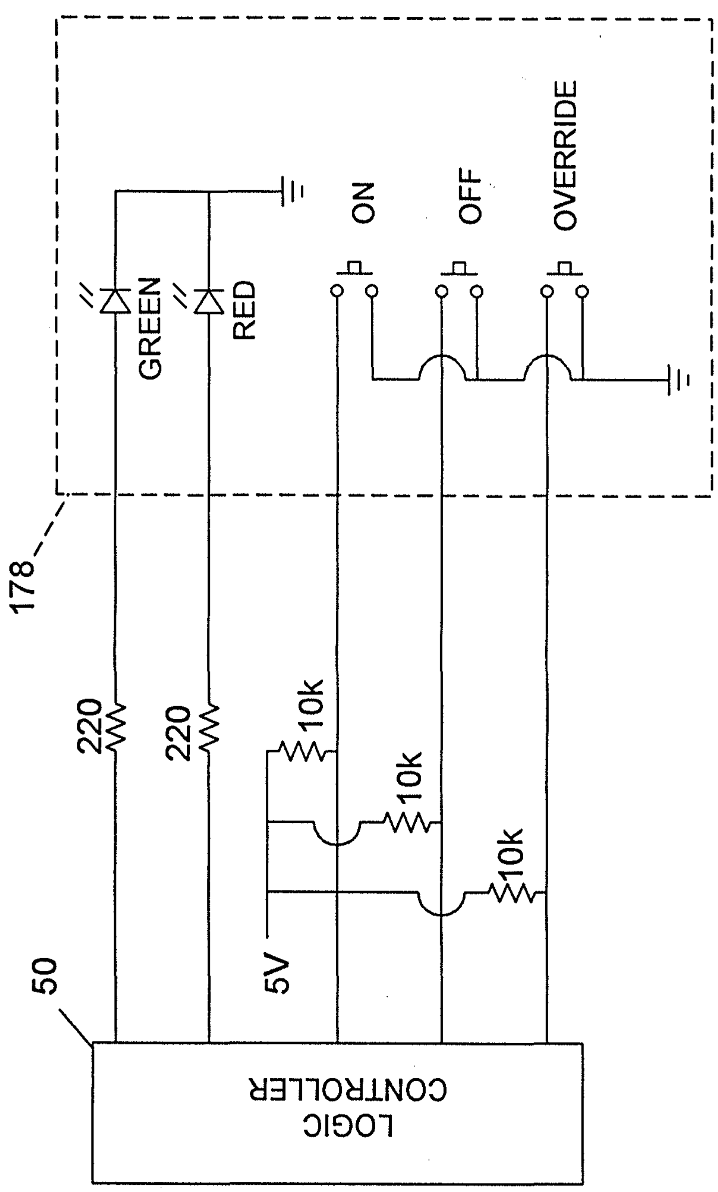


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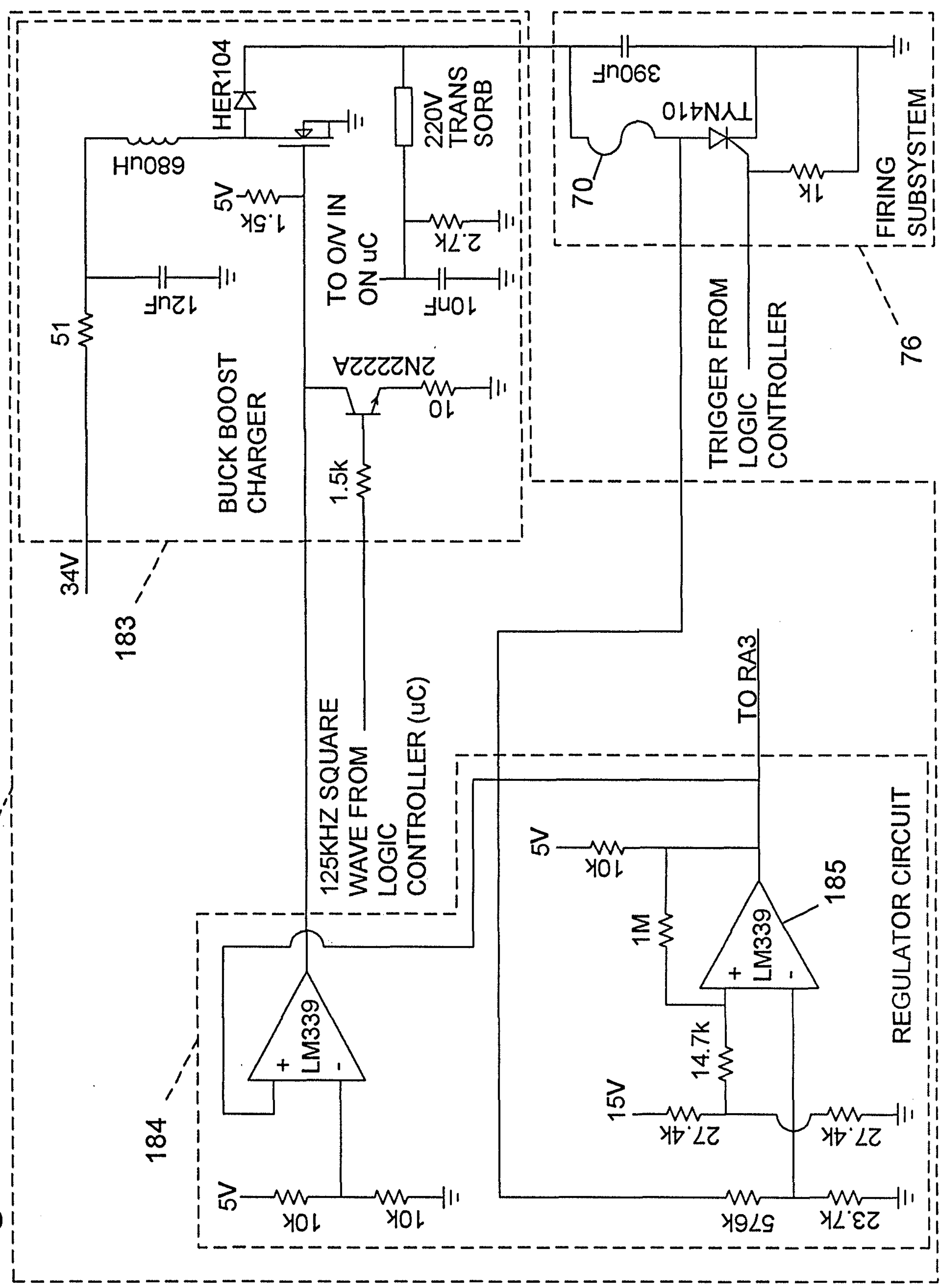
Fig. 7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680uH
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TRANS
SORB
2.7K
10nF
BUCK BOOST
CHARGER
2N2222A
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10
125KHZ SQUARE
WAVE FROM
LOGIC
CONTROLLER (uC)
390uF
TYN410
1K
FIRING
SUBSYSTEM
TRIGGER FROM
LOGIC
CONTROLLER
TO RA3
LM339
10K
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15V
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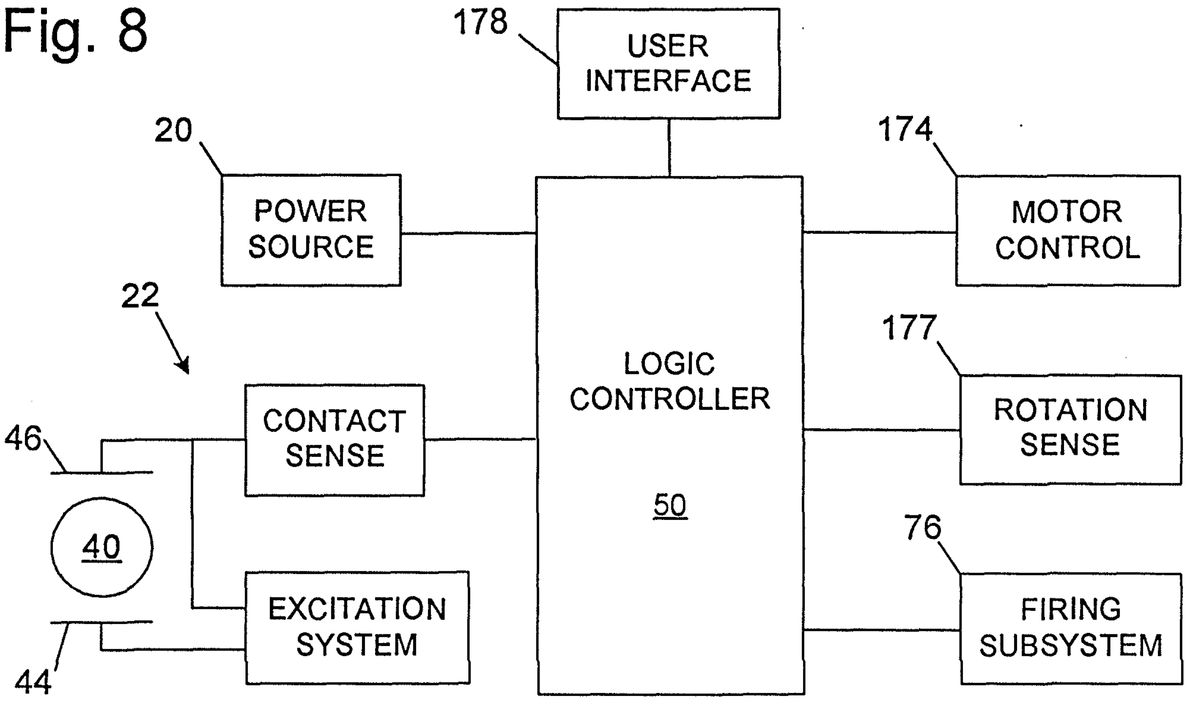
576K
23.7K
REGULATOR CIRCUIT

Fig. 8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CONTACT SENSE
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EXCITATION SYSTEM
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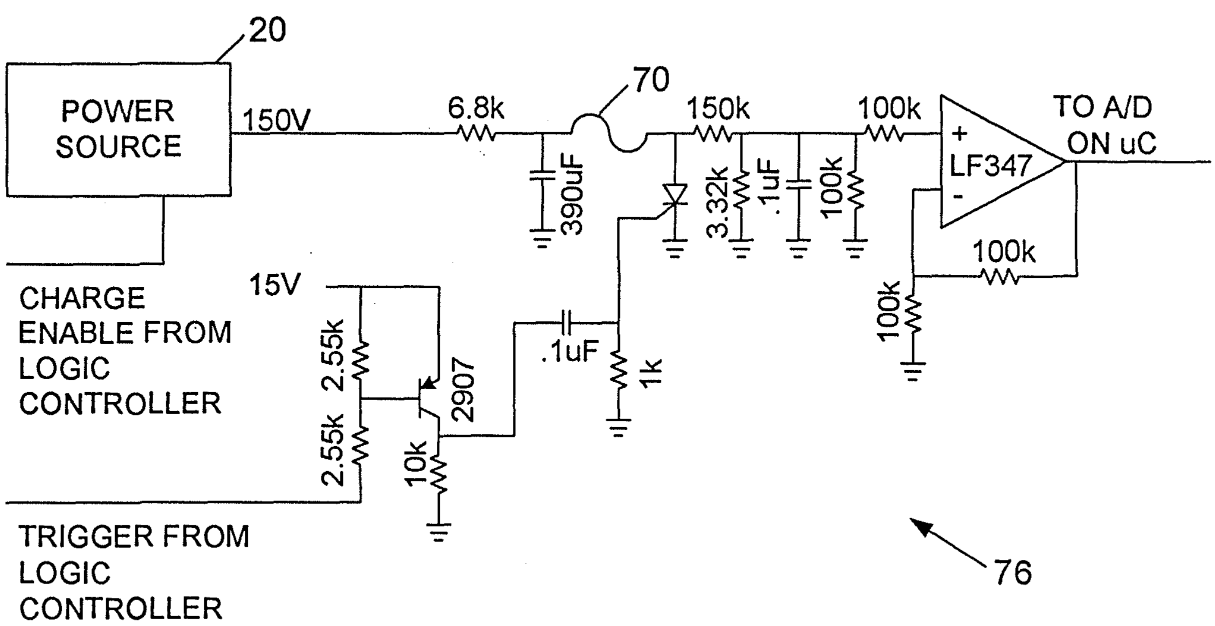
Fig. 9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.1uF
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LF347
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CHARGE ENABLE FROM LOGIC CONTROLLER
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1k
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10k
TRIGGER FROM LOGIC CONTROLLER
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Fig. 10

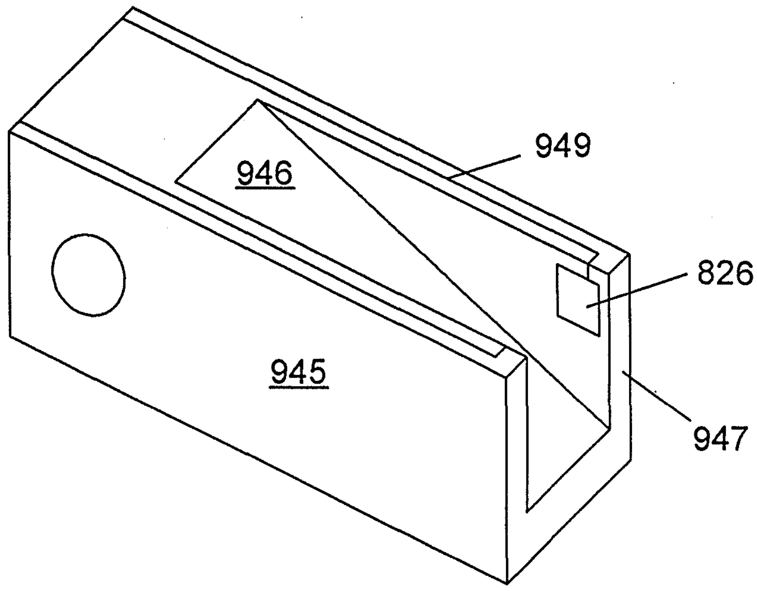

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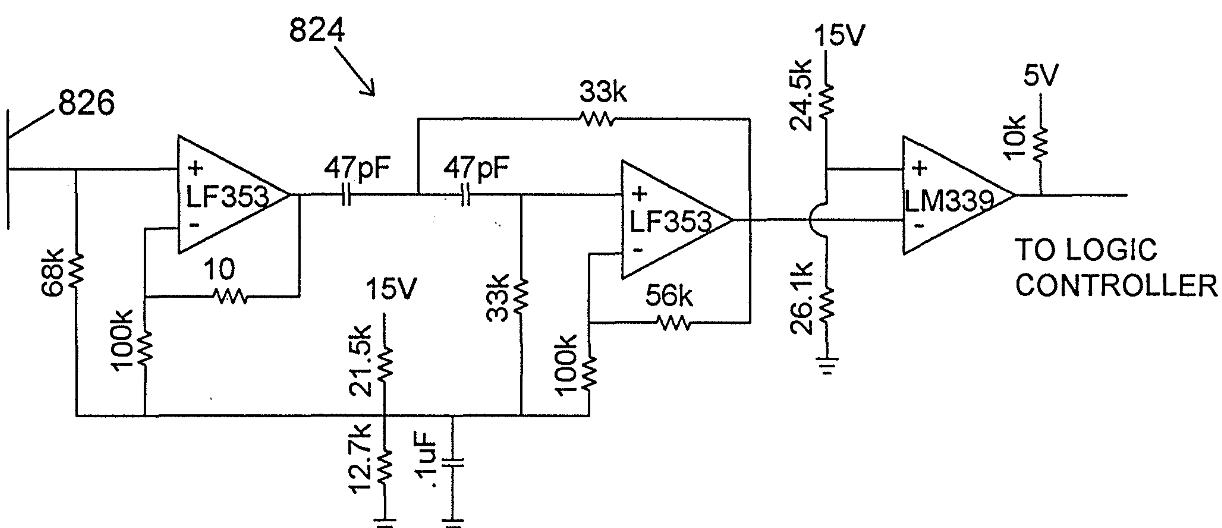
Fig. 11



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LM339
TO LOGIC
CONTROLLER
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15V
21.5k
33k
100k
56k
26.1k
12.7k
.1uF

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COMMISSIONER FOR PATENTS
UNITED STATES PATENT AND TRADEMARK OFFICE
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APPLICATION NUMBER	FILING/RECEIPT DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NUMBER
60/225,059	08/14/2000		SDT 309

FORMALITIES LETTER

OC000000005552899

Kolisch Hartwell Dickinson
McCormack & Heuser
Stephen F Gass
520 S W Yamhill Street Suite 200
Portland, OR 97204

Date Mailed: 11/14/2000

NOTICE TO FILE MISSING PARTS OF PROVISIONAL APPLICATION

FILED UNDER 37 CFR 1.53(c)

Filing Date Granted

An application number and filing date have been accorded to this provisional application. The items indicated below, however, are missing. Applicant is given TWO MONTHS from the date of this Notice within which to file all required items and pay any fees required below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

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  - either city and state or city or foreign country of the residence of each inventor.

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22409 S.W. Newland Road
Wilsonville, Oregon 97070

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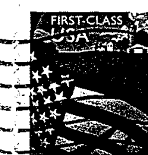

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of

STEPHEN F. GASS, JAMES DAVID FULMER, JOEL F. JENSEN, BENJAMIN B. SCHRAMM, and ROBERT L. CHAMBERLAIN

Date: January 15, 2001

Serial No. : 60/225,059

Filed : August 14, 2000

For : LOGIC CONTROL FOR FAST-ACTING SAFETY SYSTEM

Assistant Commissioner for Patents
Box Missing Part
Washington, D.C. 20231

Sir:

RESPONSE TO NOTICE TO FILE MISSING PARTS OF PROVISIONAL APPLICATION

In response to the Notice to File Missing Parts of Provisional Application dated November 14, 2000, applicants herewith submit a revised Provisional Application for Patent Cover Sheet which includes the names of the inventors and their respective city and state of residence, as requested in the Notice.

Also enclosed is a duplicate copy of the Notice to File Missing Parts of Provisional Application and a check in the amount of $25.00 for payment of the surcharge.

Please direct all future communications relating to the above-identified provisional patent application to applicants' undersigned attorney:

Stephen F. Gass, Esq.
SD3, LLC
22409 S.W. Newland Road
Wilsonville, Oregon 97070
Telephone: (503) 638-6201
Facsimile: (503) 638-8601

Please contact applicants' undersigned attorney if there are any questions or if anything further is required.

Respectfully submitted,

Stephen F. Gass
Registration No. 38,462
SD3, LLC
22409 S.W. Newland Road
Wilsonville, Oregon 97070
Telephone: (503) 638-6201
Facsimile: (503) 638-8601

CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the U.S. Postal Service as first class mail, postage prepaid, in an envelope addressed to: Assistant Commissioner for Patents, Box Missing Part, Washington, D.C. 20231 on January 15, 2001.

Stephen F. Gass
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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

INVENTOR(S)

Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
Stephen F.	Gass	Wilsonville, Oregon

[X] *Additional inventors are being named on the* 1 *separately numbered sheets attached hereto*

TITLE OF THE INVENTION (280 characters max)

LOGIC CONTROL FOR FAST-ACTING SAFETY SYSTEM

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Address					
City	Wilsonville	State	Oregon	ZIP	97070
Country	U.S.A.	Telephone	5036386201	Fax	503-638-8601

ENCLOSED APPLICATION PARTS ***(check all that apply)***

[X] Specification *Number of Pages* 47* (* prev. submitted)

[X] Drawing(s) *Number of Sheets* 11* (* prev. submitted)

[ ] Application Data Sheet. See 37 CFR 1.76

[ ] CD(s), Number

[ ] Other (specify)

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[X] No.

[ ] Yes, the name of the U.S. Government agency and the Government contract number are: ____________

Respectfully submitted,

SIGNATURE [signature]

Date 1/15/01

TYPED or PRINTED NAME Stephen F. Gass, Esq.

REGISTRATION NO. *(if appropriate)* 38,462

TELEPHONE (503) 638-6201

Docket Number: SDT 309P

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Given Name (first and middle [if any])	Family or Surname	Residence (City and either State or Foreign Country)
James David	Fulmer	Tualatin, Oregon
Joel F.	Jensen	Redwood City, California
Benjamin B.	Schramm	Los Gatos, California
Robert L.	Chamberlain	Raleigh, North Carolina

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APPLICATION NUMBER	FILING/RECEIPT DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NUMBER
60/225,059	08/14/2000		SDT 309

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Kolisch Hartwell Dickinson
McCormack & Heuser
Stephen F Gass
520 S W Yamhill Street Suite 200
Portland, OR 97204

Date Mailed: 11/14/2000

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Application Number	60/225,059
Filing Date	August 14, 2000
First Named Inventor	Stephen F. Gass
Group Art Unit	--
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Attorney Docket Number	SDT 309P

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[X] Attorney or Agent of record.

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Typed or Printed Name	Stephen F. Gass, Esq.
Signature	[signature]
Date	January 17, 2001

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more than one signature is required, see below*.

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In re Application of

Application Number: 60/225,059

Filed: 8-14-2000

Paper No. #5

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United States Patent Application Publication No. ____________, page, ________ line ________,

United States Patent Number 7,100,483, column Face, line, ________;

WIPO Pub. No. ____________, page ________, line ________.

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Mike Surles
Signature

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US007100483B2

(12) **United States Patent**
Gass et al.

(10) Patent No.: **US 7,100,483 B2**
(45) Date of Patent: **Sep. 5, 2006**

(54) **FIRING SUBSYSTEM FOR USE IN A FAST-ACTING SAFETY SYSTEM**

(75) Inventors: **Stephen F. Gass**, Wilsonville, OR (US); **Andrew L. Johnston**, Redwood City, CA (US); **Joel F. Jensen**, Redwood City, CA (US); **Sung H. Kim**, Palo Alto, CA (US); **David A. Fanning**, Vancouver, WA (US); **Robert L. Chamberlain**, Raleigh, NC (US)

(73) Assignee: **SD3, LLC**, Wilsonville, OR (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 527 days.

(21) Appl. No.: **09/929,240**

(22) Filed: **Aug. 13, 2001**

(65) **Prior Publication Data**

US 2002/0020263 A1 Feb. 21, 2002

Related U.S. Application Data

(60) Provisional application No. 60/225,056, filed on Aug. 14, 2000, provisional application No. 60/225,057, filed on Aug. 14, 2000, provisional application No. 60/225,058, filed on Aug. 14, 2000, provisional application No. 60/225,059, filed on Aug. 14, 2000, provisional application No. 60/225,089, filed on Aug. 14, 2000, provisional application No. 60/225,094, filed on Aug. 14, 2000, provisional application No. 60/225,169, filed on Aug. 14, 2000, provisional application No. 60/225,170, filed on Aug. 14, 2000, provisional application No. 60/225,200, filed on Aug. 14, 2000, provisional application No. 60/225,201, filed on Aug. 14, 2000, provisional application No. 60/225,206, filed on Aug. 14, 2000, provisional application No. 60/225,210, filed on Aug. 14, 2000, provisional application No. 60/225,211, filed on Aug. 14, 2000, provisional application No. 60/225,212, filed on Aug. 14, 2000.

(51) **Int. Cl.**
B26D 5/00 (2006.01)

(52) **U.S. Cl.** .... 83/58; 83/DIG. 1; 83/522.12; 192/129 R

(58) **Field of Classification Search** .... 83/DIG. 1, 83/62.1, 62, 72, 58, 76.7, 788, 581, 471.2, 83/477.1, 477.2, 522.12, 526, 397.1, 522.121; 144/154.5, 356, 384, 391, 427, 286.5; 29/708, 29/254, 413; 324/550, 424; 408/5; 56/10.9, 56/11.3; 192/192 A, 129 R, 130; 102/202.7; 89/1.56; 137/68.12, 72, 76; 188/5, 6; 169/57, 169/59, 42, DIG. 3; 74/2; 403/2, 28; 411/2, 411/39, 390; 335/242, 1, 132; 318/362; 241/32.5; 337/239, 148, 1, 5, 10, 17, 140, 337/170, 190, 237, 401, 290, 404, 405; 218/2, 218/154; 307/639, 328, 115, 326, 142, 117, 307/126, 131; 451/409; 280/806; 297/480
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

0,146,886 A 1/1874 Doane et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CH 297525 6/1954

OTHER PUBLICATIONS

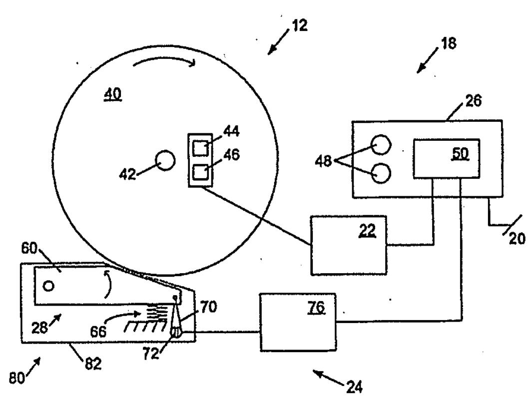
Gordon Engineering Corp., Product Catalog, Oct. 1997, pp. cover, 1, 3 and back, Brookfield, Connecticut, US.

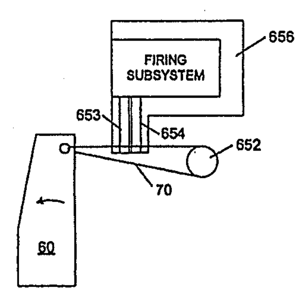
Primary Examiner—Timothy V. Eley
Assistant Examiner—Jason Prone

(57) **ABSTRACT**

Cutting machines with high-speed safety systems, and firing subsystems used in high-speed safety systems, are disclosed. The cutting machines may include a detection system adapted to detect a dangerous condition between a cutting tool and a person. A reaction system performs a specified action, such as stopping the cutting tool, upon detection of the dangerous condition. A fusible member or explosive may be used to trigger the reaction system to perform the specified action. A firing subsystem may be used to fuse the fusible member or fire the explosive upon detection of the dangerous condition.

18 Claims, 8 Drawing Sheets





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	5.	Request for access	8-5-15
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