Safety Interlock for Angularly Misdirected Power Tool

Power would be turned off when the tool was aimed in the wrong direction.

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A proposed safety system would effect an inhibitory action whenever a power tool was aimed in a direction outside a prescribed range of allowable directions. The power tool could be a welding torch, blowtorch, laser, drill, or gun, for example. The inhibitory action could be turning off the supply of gas or electric power to the tool; in the case of a gun, the inhibitory action could be actuation of a mechanical trigger stop.

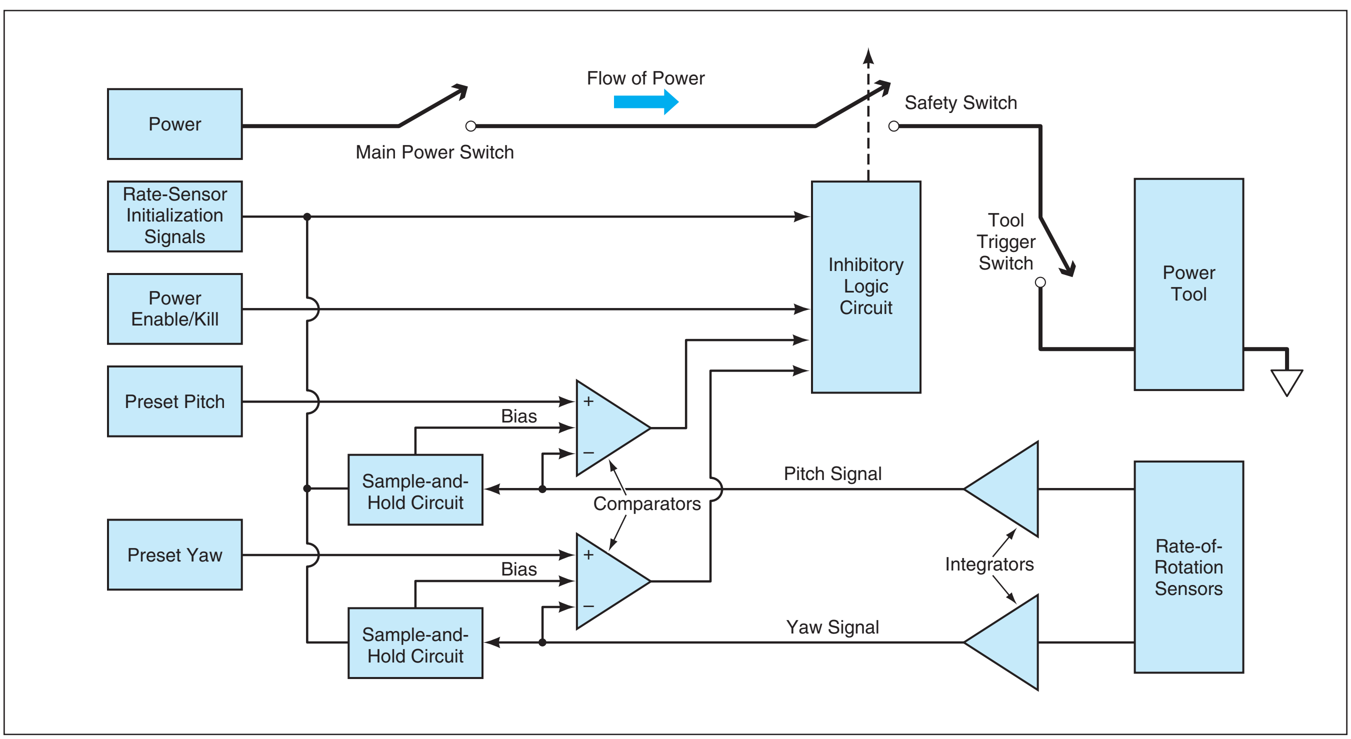
The safety system would include at least two rate-of-rotation sensors (one for pitch and one for yaw), an electronic circuit that would generate an "inhibit" command, and a mechanism that would effect the inhibitory action upon receipt of the "inhibit" command. The two rate-of-rotation sensors could be based on gyroscopes and could be combined in a single package; the preferred package would be a commercial dynamically tuned two-axis-gyroscope unit that has a rate range of 200° per second and a steady-state power consumption of ≈1 W. The rate-of-rotation sensors should be positioned so that their principal axes of pitch and yaw intersect at approximately the location designated as the center of the tool.

The figure schematically depicts the main power-control circuit and the safety system as they would be configured in a typical application to an electrically powered tool. Electric power would be supplied to the tool through three switches: a main (manually actuated switch), a safety switch under control by the circuitry described below, and a tool-trigger switch. The electronic circuitry in the safety system would include integrators that would convert the outputs of the yaw- and pitch-rate sensors to yaw- and pitch-angle signals, respectively.

The yaw- and pitch-angle signals would be fed to the inverting inputs of yaw- and pitch-angle-signal comparators, while preset yaw and pitch signals would be fed to the noninverting inputs of these comparators. Along with rate-sensor-initialization signals, the yaw- and pitch-angle signals would also be processed through sample-and-hold circuits, the outputs of which would be used to bias the comparators such that each comparator would put out a logical "1" when the corresponding yaw or pitch angle deviated from a desired aiming direction by more than a preset amount of yaw or pitch, respectively.

The outputs of the comparators would be fed to an inhibitory logic circuit that would allow power to be supplied to the tool when (1) the rate-sensor-initialization signal was asserted, (2) the operator had pressed a "power enable/kill" push-button switch to signal the intention to operate the tool, and (3) the tool was aimed within the angular bounds described above. Under all other conditions, the inhibitory logic circuit would generate the "inhibit" command, which, in this case, would cause the safety switch to shut off power to the tool. If the tool were a gas-fed welding torch, then the inhibitory mechanism could include an electrically actuated valve instead of (or in addition to) a safety switch. If the tool were a gun, then the inhibitory mechanism could be an electromechanical trigger stop.

The sequence of operation of the tool and safety system would be the following: The pitch and yaw angular limits would have been preset by the operator. The operator would point the tool at



Power To Operate a Tool would be fed through three switches, one of which would be part of the safety system. The safety switch would shut off power to the tool, except when the tool was aimed within preset angular bounds and the operator had signaled the intention to operate the tool.

the work site and would assert the rate-sensor-initialization signal (this could be done by pressing a push-button switch). The initial orientation of the tool would then be "remembered" as the desired aiming direction ("homing" direction). Then the operator would press the "power enable/kill" button. Finally, the operator would begin to operate the tool by pulling its trigger. Whenever the tool was aimed outside the angular limits, safety system would shut off power to the tool.

Unlike safety systems based on mechanical restraints, the proposed system would not make the operator's task more difficult or adversely affect the quality of the work. Unlike magnetic- and optical-sensor-based safety systems, the proposed system would not require the setup and calibration of an external reference subsystem. Unlike an optical-sensor-based safety system, the proposed system would not be susceptible to interference by ambient light. In comparison with a magnetic-sensor-based system, the proposed system would be less susceptible to electromagnetic interference. The proposed system is also expected to cost less than the optical and magnetic systems do.

The proposed system would have some limitations:

- The rate-of-rotation sensors would be sensitive to the rotation of the Earth. The rate of buildup of angular error due to rotation of the Earth should be no greater than about 0.25° per minute.
- Some drift errors may be generated in integration of the outputs of the rate-of-rotation sensors. Errors of this type are typically about 1° per minute.
- The system would inhibit operation in the event of translational mispositioning of the tool.
- The system would not prevent injury to a person who stepped in front of the tool, in a region that fell within the preset angular bounds.

This work was done by Larry C. Li of **Johnson Space Center.** *Further information is contained in a TSP (see page 1).*
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