1.0 Introduction

Johnny Belay is a remote controlled belaying device for artificial rock climbing. It is installable on the floor of any indoor rock climbing gym. Johnny Belay has three major functions. First, Johnny Belay replaces the tasks of a traditional human belayer: tension control, lowering, and braking. Second, Johnny belay provides the safest possible experience for any climber. Finally, Johnny Belay has additional features new to the climbing experience such as assist tension for the climber and instantaneous response to dynamic climbing moves. Figure 1 pictures the typical installation and use of Johnny Belay.
2.0 Mechanical Design

2.1 Exterior Design

All mechanical components are mounted on a single aluminum base plate and are enclosed in a robust housing. The entire unit covers a floor area of less than one square meter. The package is bolted to the floor approximately one meter in front of a climbing wall. Figure 2 shows the Johnny Belay unit installed in front of a climbing wall.

Figure 2: Housing Assembly

2.2 Interior Design

Johnny Belay is powered by a brushed DC servomotor. The motor has several notable characteristics, including a high continuous stall torque of 56 in-lbs and a fast no load speed of 2000 rpm. The motor is coupled through a shaft to a magnetic particle brake. The function of the brake is to lower the climber as well as support the climber in the event of a fall. The motor shaft is coupled to the spool shaft through a reducing belt drive at a 4:1 ratio. In addition, an emergency mechanical overspeed clutch is mounted on the end of the rope spool. A manual lowering override (not shown), consisting of a band brake and lever, allows an assistant to safely lower the climber to the ground if the emergency clutch engages. The interior components are shown in Figure 3.
Figure 3: Mechanical Assembly
3.0 Electronics Design

3.1 User Interface

The user interface for the controls system consists of two remote controls clipped onto each side of the climber’s harness. There are four input commands on the remote controls: “increase tension”, “decrease tension”, “lower”, and “stop.” Figure 4 shows one the remote controllers. Tension is varied using the rubberized gray buttons and lowering is activated via the red trigger. The stop button, which is not shown here, is engaged by the palm of the climber’s hand.

![Remote Controller](image)

Figure 4: Remote Controller

The controllers are wired to a small circuit board through a five pin XLR connection. This board contains an RF transmitter and is powered by a single 9 V battery. The assembly is housed in a protective foam package and is attached on the back of the climber’s harness.
3.2 Signal Processing

The signals from the transmitter are sent to an RF receiver mounted on the base of Johnny Belay. A Stamp programmable control microprocessor receives and processes the RF signal as well as motor feedback. The Stamp indirectly controls the motor and the brake via a proprietary Baldor controller/amplifier. It is equipped with two separate control cards, one for the motor and one for the brake. The motor controls the tension of the rope and the brake provides a force to support the weight of the climber. Figure 5 depicts a basic schematic of the electronics design.

4.0 Safety

Johnny Belay is a fail-safe design for two major reasons. First, the design of the exterior housing and the placement of the unit do not inherently place individuals on the gym floor at risk. Second, in operating mode, the climber using the device is protected by a redundant braking system. The magnetic particle brake automatically senses and supports the climber in the event of a fall. The climber can also activate the brake by pressing the stop button on the remote controls. In addition to the magnetic particle brake, an emergency mechanical clutch protects against uncontrolled fall by preventing spool over-speed. Such an emergency could occur in the event of a power outage or the failure of critical electrical components. A purely mechanical friction brake allows gym staff to lower the climber if the emergency brake engages.
5.0 Conclusion

The picture below captures the complete prototype of Johnny Belay.

Figure 6: Overview of Johnny Belay Components

Several possibilities exist for improvement of a future version of Johnny Belay. For example, wheels could be mounted on the base for easy transport and repositioning in the gym. Implementation of a hands-free user interface could be achieved through voice-control technology. An additional software package could monitor parameters such as spool speed and climbing time and output workout performance data such as average climbing speed and calories burned. Figure 7 and 8, on the next page shows Johnny belay in use.
Figure 7, 8: Johnny Belay in use