World Elevator Codes for the Ultimate in Passenger Safety

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ABSTRACT

Electrical & mechanical failures in elevators that allow them to leave a floor with opened doors or cause them to or plummet in the overhead, present a hazard to life and limb. In the absence of code requirements, few products have been developed to prevent those accidents and those few have met with limited success. However, as the new world codes are changing to prevent those hazards, a new innovative spirit has been released creating many new product designs. This paper is a discussion of the new codes and new products designed to meet them.

INTRODUCTION

As we look around the world of today, one can marvel at the work ethic and the geniuses of mankind who have made today's world possible, by their inventions of the first tool, the wheel, the pulley system, the steam engine, the gasoline engine, electricity, the electric motor the relay, the transistor, the microprocessor, the automobile, airplane, and rocket ships to the moon and beyond. These all come from men with dreams and visions of making things better; plodding through many failed experiments which only inspired them to their eventual successes.

The tall buildings of today are in every major city of the world and the monuments to the geniuses of mankind are in the likes of the Empire State Building, The World Trade Center, The Sears Tower, and the Petronas Towers of Kuala Lumpar to name a few. But just think, none of these would have been possible without the elevator, and in fact, would not have been possible without the safe elevator. While some form of elevators have existed for thousands of years, it was Elisha Graves Otis who is credited with inventing the safe elevator. Otis attached saw tooth iron bars to the guide rails. On the top of the elevator he used a wagon spring, which was connected to mechanical linkages and safety dogs. (Fig. 1) The rope was attached to the center of the wagon spring and under normal conditions the wagon spring was held nearly flat by the weight of the elevator. This kept the safety dogs away from the saw tooth bars. If the hoist rope broke however, the spring would return to its original shape, forcing the mechanical linkages, and then the safety jaws into the saw toothed bars preventing the elevator from falling.

At the Crystal Palace Exhibition in 1853, Otis demonstrated his invention by standing on the platform, raising the elevator with the rope, and then ordering the rope cut. The crowd roared its approval night after night as Otis removed his hat and exclaimed, "All safe, gentlemen, all safe". (fig 2)

While the news called him daring and accused him of sensationalism, the public fixed upon another word – "safety". An acceptance was born without which our cities would not exist as we know them today. [1]

Many years ago Elisha Otis invented the safety gear to prevent free fall of an elevator in the down direction. In the absence of new elevator codes only a few devices have been invented to prevent elevators from crashing in the overhead or leaving the floor with doors open.

As the elevator codes are changing many companies are developing devices such as the sheave jammer, bi directional safety, and rope brake to prevent crashing in the overhead. Canada's code is more stringent and also requires a device to prevent the elevator from leaving the floor with open doors. This paper discusses these devices and some changes needed to meet more stringent codes.

Down Direction Overspeed Protection

Our elevators have come a long way since Otis, working today with highly sophisticated Microprocessors , including motor drive schemes from SCRs, and Variable Voltage Variable Frequency. Elevator codes have also come a long way, with hundreds of pages of requirements, and the elevator down direction safety of today comes in many designs.

The most common safety today is mounted under the elevator and is activated by a speed governor which will clamp the governor rope when the elevator overspeeds in the down direction. (Fig. 3) When the governor rope is clamped, it will trigger the safety which then contacts the guide rails to stop the elevator.

Today's guide rails are smooth steel and the safety jaws dig into them as in instantaneous safety (fig 4) or clamp the rails as in a wedge clamp safety (fig 5) or a flexible guide clamp safety. (fig 6)

For other variations of safety gear see Evolution of a Safety Gear by John Inglis in Elevator Technology, a proceeding of Elevcon **'98.**

As is required by elevator codes around the world, down direction safeties will activate during overspeed conditions caused by any failure, including hoist rope breakage. By consensus,

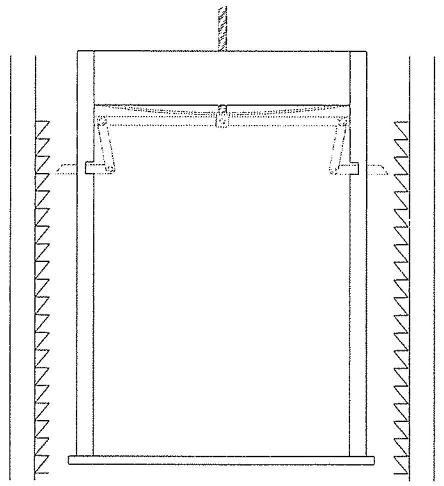

Figure 1

Figure 2 [1]

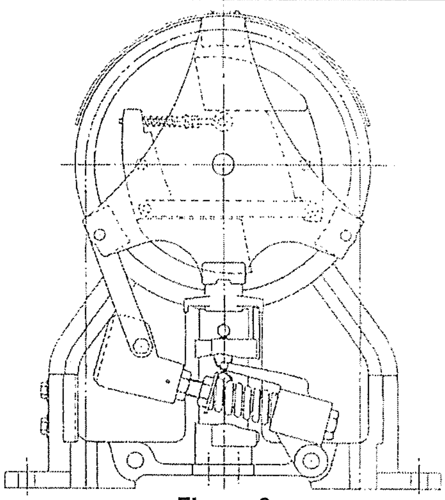

Figure 3

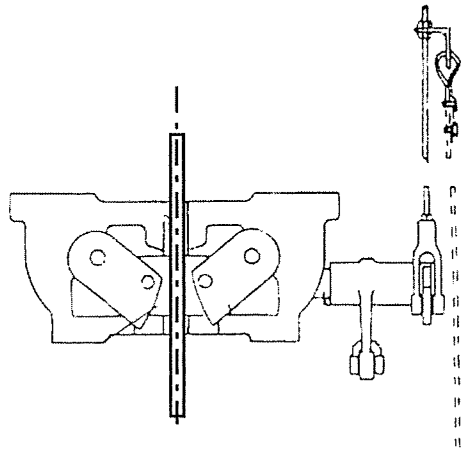

Figure 4

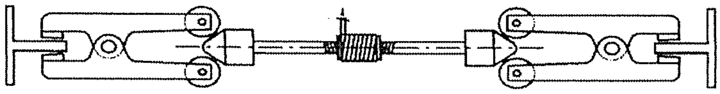

Figure 5

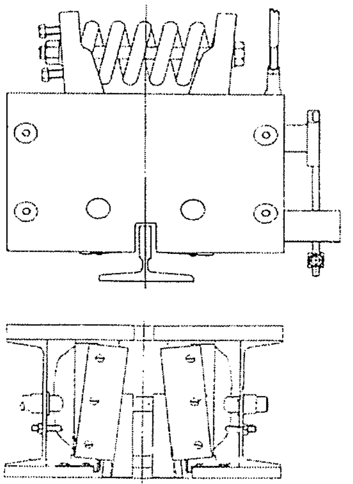

Figure 6

these devices provide more than adequate protection for elevators - but only if they are traveling in the down direction.

Up Direction Overspeed

There are very few codes that address a much more common occurrence, elevators falling up. When an elevator is less than half loaded, the counterweights generally weigh more than the elevator. In this condition, any number of mechanical failures will cause/allow the car to fall up. Falling up can easily be as dangerous as falling down.

It is true that when traditional safeties are attached to the counterweights, the elevator in effect has an up direction safety. However, counterweight safeties are rarely employed except where required. They are generally required when the space under the counterweights is occupied.

To this writer's knowledge, it was nearly 100 years after Otis demonstrated his safety at the Crystal Palace, that the first true up direction safety was invented. This came from the Dutch firm of Machinefabriek P.M. Duyvis. The Duyvis device was a rope brake which was air operated and clamped the elevator ropes to stop the car in the event of overspeed in either direction. (Fig. 7) [2] The present day Bode ® rope brake, also air operated, is based on many improvements to the original Duyvis design. (Fig 8)

Meeting New Codes

Lacking any code requirements for an up direction emergency brake, I could find very little documentation or discussion on the topic until the 1990 Canadian Code (B44) began to be developed. As soon as code authorities started planning for such a device, the innovative spirit was again released and new products were designed to address them. Note: When the 1990 Canadian code was adopted, it did in fact have a requirement for a device to activate in the event of up direction overspeed as well as the elevator leaving the floor with opened doors.

To meet this code, Northern Elevator developed a traction sheave brake called the "Sheave Jammer." (Fig. # 9) This is a traction sheave brake, held in the normal running position by a magnetic solenoid. When the solenoid is de-energized, the springs extend, forcing the carrier and frictional plate assembly against the rim of the traction sheave. If the traction sheave is rotating, the frictional plate will be forced sideways and heavy disc springs will compress causing a braking force which stops the car. [3]

A different approach was taken at Hollister-Whitney. A device such as the "Sheave Jammer" would not address the problem of an elevator slipping traction. When an elevator slips traction, it can move without the sheave actually turning. A car mounted up direction safety was also ruled out because, if mis-adjusted, it could stop too fast throwing passengers against the ceiling.

After considerable thought and experimentation Hollister Whitney decided on a rope brake design and patented their Rope Gripper™. The Rope Gripper™ is an electromechanical device that uses a spring activated movable shoe to clamp the hoist ropes against a stationary

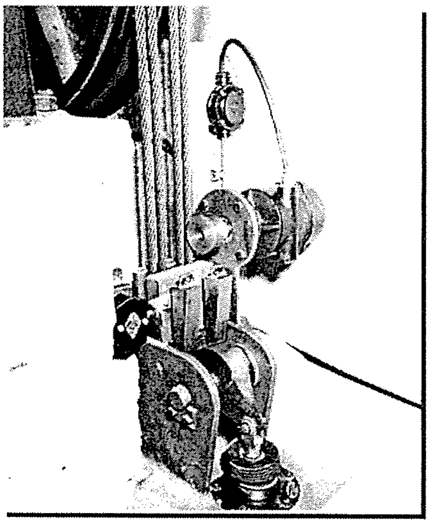

Figure 7 [2]

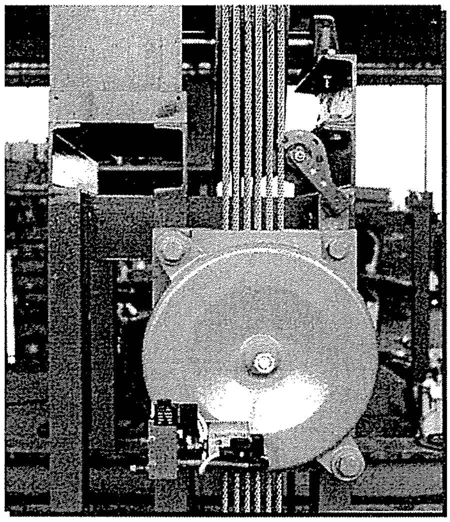

Figure 8 [2]

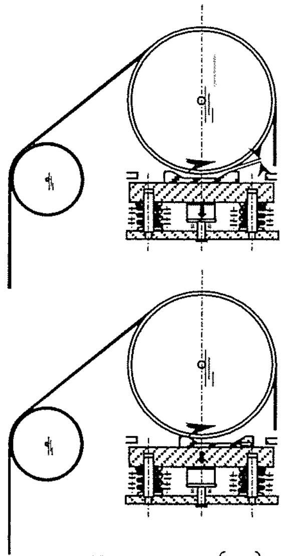

Figure 9 [3]

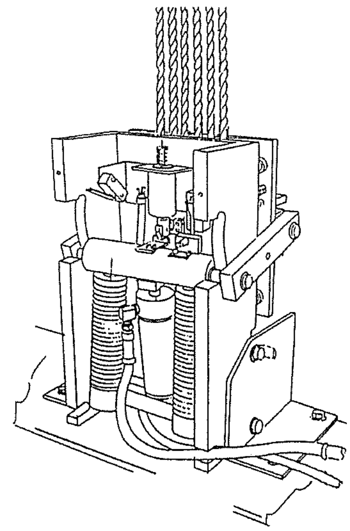

Figure 10 [4]

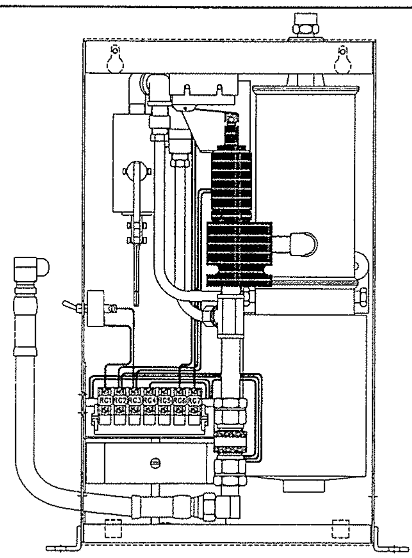

Figure 11

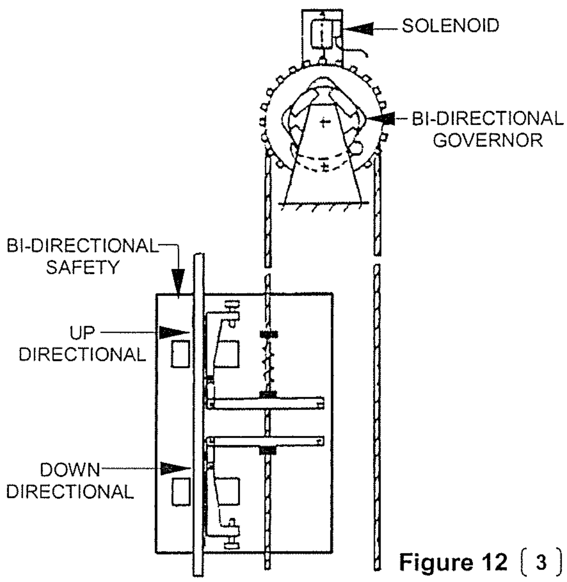

Figure 12 [3]

shoe. (fig 10) This design uses two medium strength springs pushing up on a shaft which then rotates over a stationary cam. The cam is designed to have a changing mechanical advantage. This advantage allows the use of a small magnetic solenoid to hold the springs which are a hundred times more powerful than the solenoid itself.

In this loaded position (not clamping the ropes) the elevator is allowed to run. Disconnecting power from the solenoid forces the movable shoe toward the stationary shoe with increasing force.

With the ropes clamped, the mechanical advantage multiplies the spring pressure causing a powerful clamping force. This force becomes constant even if the springs extend further.

For the purpose of compressing the springs, a hydraulic piston is placed between the springs with a pumping unit used solely for that purpose (Fig 11) While a rupture (failure) in the hydraulic system may prevent the loading of the Rope Gripper™ it will not apply it or prevent it's application in the event it is needed.

Hollister Whitney decided not to ignore the possibility of overspeed or leaving the floor with open doors should there be a power failure, not addressed in the Canadian code. Providing a battery backup to monitor activation methods seemed impractical. It was deemed safer to apply the Rope Gripper™ and simply have automatic reset when power was restored. A hand pump was also provided to open the brake allowing for manual movement of the elevator for passenger evacuation during a power failure. [4]

After the adoption of the 1990 Canadian Code there was another lull in the development of up direction brakes. The new European Lift Directive , 95/16 EC & EN81-V2, only addressed up direction overspeed, but once again we began to see new designs.

Walking around the Interlift Exhibition in Augsburgh, Germany, in September of 1999, it was amazing to see how many companies had designed products to meet the requirements of an up direction overspeed protection device. Hollister Whitney's design was a reduced cost Rope Gripper™ using a battery backup and a hand pump for loading.

Others shown were in the form of a car safety for the up direction, often coupled with a down direction safety.(bi-directional) (fig 12) When overspeed occurs in either direction, a ratcheting device engages to stop the governor sheave. Due to the friction of the governor rope in the sheave, a force is created that applies the safety in the direction of travel. Because the up direction safety is designed to stop an empty car with the counterweights attached, it need not be as strong as the down direction safety which must stop a free falling car that is loaded to capacity. The new European code require the cost of the up direction safety and its activation means. With very little additional cost, this device could have met a more stringent code. By adding spokes on the governor sheave and a solenoid as shown,(fig12) removing power from the solenoid would stop the sheave, allowing the safeties to set, particularly when leaving the floor with open doors. [5]

Conclusion

The ability of mankind to design and manufacture new product is limitless. We have gone to the moon and the planets beyond. Elevators, said to be the safest form of transportation in the world, are comprised of many mechanical and electrical devices which are prone to wear and/or eventual failure. Code makers have a responsibility to the riding public to address situations where this potential failure may cause injury or death. Today's code, while written to encompass products that have already been designed, should be based on the greater public safety. We can rest assured that the creative spirit will again be released and that inventors can be relied upon to develop products that will meet that higher standard. At that time we can all say what Elisha Otis said, "All safe gentlemen, all safe"

Acknowledgements

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About The Author

Walter Glaser, Vice President of G.A.L. Manufacturing Corp. and of Hollister Whitney Elevator Corp., a 40 year industry veteran, is active in the everyday management of both companies. With a background in electrical and mechanical engineering, Glaser has been involved in many product designs and has many international patents to his credit.