February 1998

ISSN 1097-7589

Vol. 1 No. 1

Triodyne Inc.

A SAFETY JOURNAL HIGHLIGHTING CRITICAL SAFETY DEVELOPMENTS

SAFETY ALERT

PRICE: $5.00

Anti-Hair Entanglement

by Ralph L. Barnett*

Abstract

When bathers or swimmers place their heads in the vicinity of active pool drains, their hair may become entangled in the drain cover or grating. For the period 1978 to 1996, the Consumer Product Safety Commission reports 49 entanglement incidents (including 13 deaths) where the victims' heads were held under the water in spas, hot tubs, and whirlpools. This paper outlines several drain cover concepts that may mitigate or eliminate the entanglement danger.

I. INTRODUCTION

Children and adults use swimming pools and hot tubs for exercise, relaxation, competition, exhibition, romance, exhilaration and therapy. When swimmers and bathers frolic underwater they risk exposing their hair to active pool drains. For example, swimming a circuit to and from a drain is a common aquatic exercise that brings the head into the vicinity of the drain where strands of hair may be entrained into the drainage flow and pass through the apertures in conventional drain gratings.

When hair strands are drawn through drain gratings hair entanglement may proceed by the knotting or wrapping mechanisms illustrated in Figures 1a and 1b respectively. Both mechanisms are sufficiently aggressive that a bather may be trapped even in the face of heroic intervention. Drain covers can be designed to avoid hair entanglement or to allow escape. Several concepts are presented that are the subject of pending patent applications.

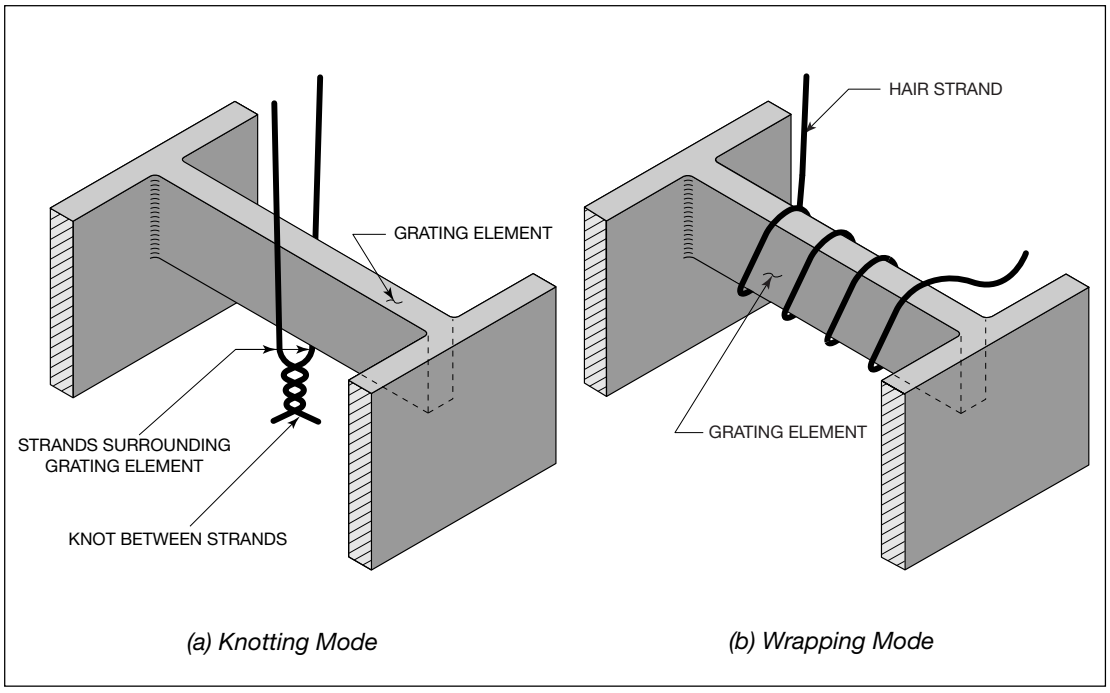

Figure 1 – Hair Entanglement Models

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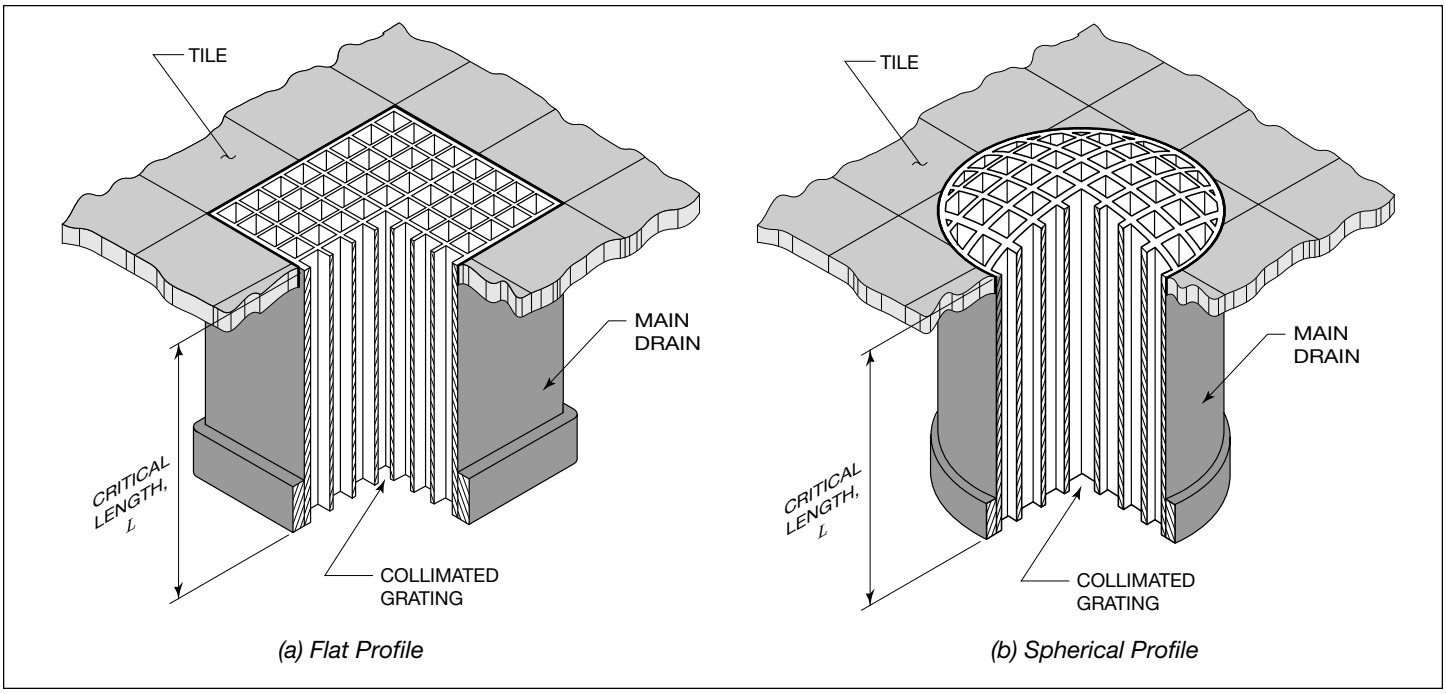


(a) Flat Profile *(b) Spherical Profile*

Figure 2 – Collimated Gratings

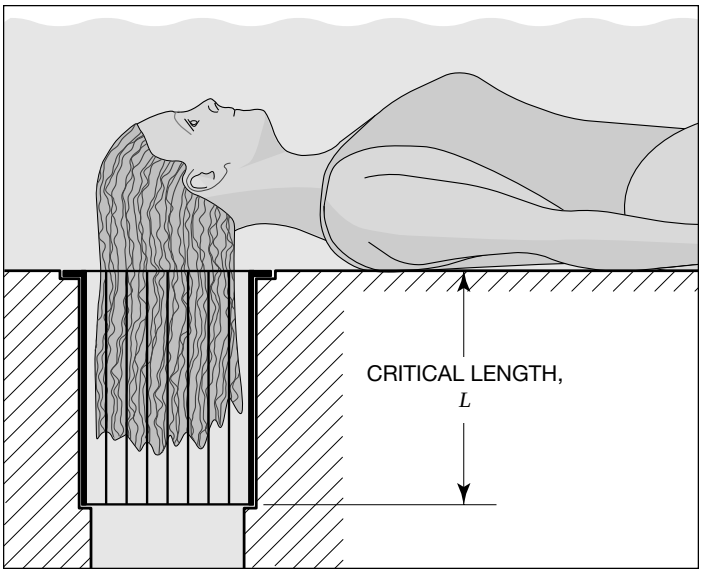
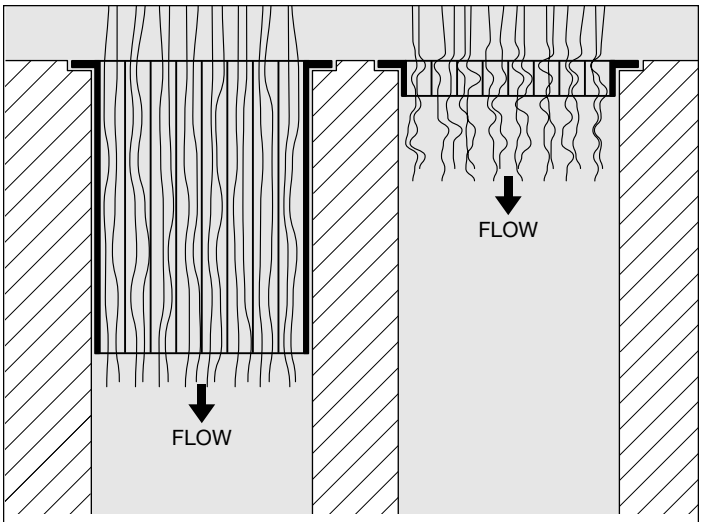


Figure 3 – Critical Length



(a) Laminar Flow Discharge *(b) Turbulent Flow Discharge*

Figure 4 – Downstream Laminar Flow

II. COLLIMATED GRATINGS

By extending the vertical dimensions of most conventional drain gratings, one obtains a series of prismatic tubes such as shown in Fig. 2. The resulting collimated gratings provide two unique countermeasures against the danger of hair entanglement.

The most important safety feature of collimated gratings is associated with "critical length" as defined in Fig. 3. It is observed that hair strands shorter than the critical length L cannot lasso a grating element by knotting. Furthermore, the wraparound entanglement mode can never occur. Clearly, as L gets larger the percentage of the population who will enjoy total protection against hair entanglement increases. Main drains are currently available to accommodate a critical length of 12".

A second safety property of collimated gratings comes into play when hair strands are longer than L. Here, hair from neighboring grating tubes may intertwine. Figure 4 suggests that turbulent flow on the downstream side of gratings has a greater tendency to form knots in hair strands than laminar flow. We note that for circular tubes of diameter D, the ratio D/L may always be designed small enough to preclude turbulence.

Note that the spherical profile shown in Fig. 2b, minimizes another pool drain hazard – the formation of a dangerous

vacuum when the grating is completely covered by a portion of the bather's body. In a recent entrapment incident, a young women sat on a one foot square grating and was held down by a one ton force. Six professionals on the scene were unable to break the vacuum and save her life. A second type of tragedy associated with drain vacuums involves the disembowelment of children who sit on the gratings. At present medical science cannot reattach their intestines and their survival entails a lifetime of intravenous feeding.

III. CANTILEVERED GRATING ELEMENTS

Conventional grating elements, such as shown in Fig. 1, consist of horizontal prismatic beams supported at both ends. As indicated in Fig. 1a, no escape geometry is provided in the knotting mode. Furthermore, a single wrap around a straight element can entrap a strand of hair. On the other hand, cantilevered elements always provide an escape geometry as illustrated in Fig. 5a. Indeed, the steep angle on the bottom surface of the element leads to shedding of the hair lasso. The effect of the tapered cantilever profile illustrated in Fig. 5b also precludes wrapping entanglement by the same shedding mechanism.

Figure 6 depicts various drain grating designs which incorporate only cantilevered elements. The domed profile illustrated in Fig. 6c makes it very difficult to fully cover the drain with the human body. This safety feature minimizes the development of a dangerous vacuum.

IV. CUTTING EDGE GRATING ELEMENTS

Disengagement of entangled hair from drain gratings is restricted by forces developed at the bottom surface of the grating elements. If these surfaces are fashioned into a cutting edge as shown in Figure 7, hair strands may be severed to release a bather. The edges may incorporate some of the modern “stay sharp” profiles. Grating materials must be selected to sustain the integrity of the cutting edges in the face of harsh pool and hot tub chemistry. Furthermore, the grating apertures must be designed to preclude finger contact with the sharp edges at the bottom of the grating.

V. LIFTABLE GRATINGS

Unsecured gratings will not hold down a person whose hair has become ensnared. Most conventional gratings are secured to pool surfaces or main drains using fastening systems that cannot be breached by human strength. It is, of course, a simple matter to design detented gratings that will “pop up” or breakaway at modest force levels.

It should be noted that liftable gratings are sometimes counterindicated by overall safety considerations. Some drainage systems require secured gratings to protect against the hazards of tripping, entrapment, and disembowelment.

VI. CONCLUDING REMARKS

1. There appear to be no gratings on the market that address the hair entanglement hazard.

2. Properly designed drainage systems must simultaneously address the dangers of hair entanglement, tripping, entrapment, undertow, and evisceration.

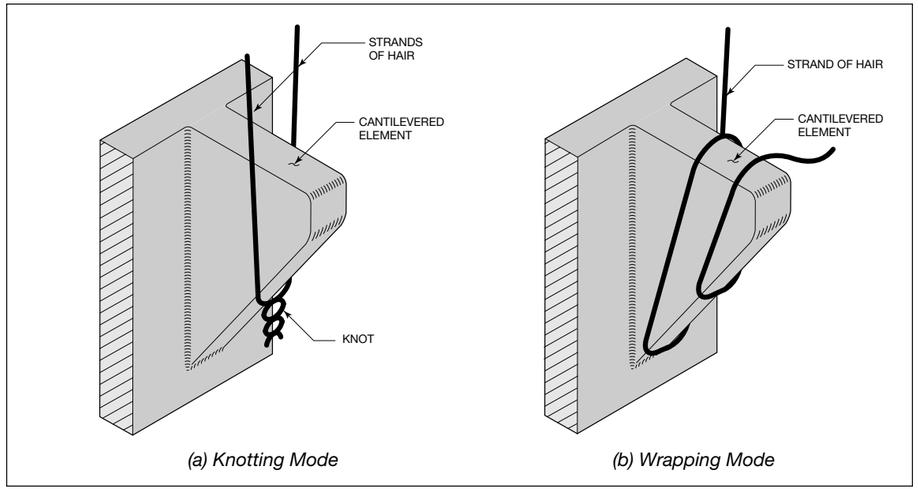
3. Various countermeasures may be used in combination to solve the various drainage hazards. For example, Fig. 8 illustrates an unsecured domed collimated drain that minimizes vacuum entrapment and hair entanglement.

4. The assertions relative to the laminar flow illustrated in Fig. 4 were demonstrated using the pool simulation fixture shown in Fig. 9.

5. A method of retrofitting a conventional grating with a collimated design is shown in Fig. 10.

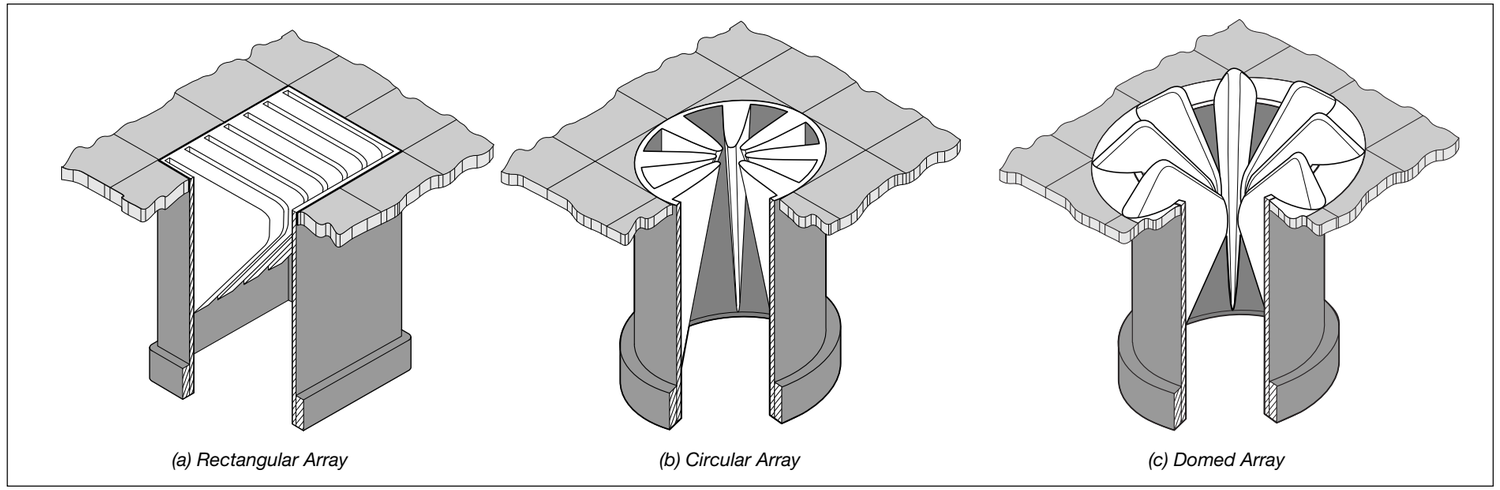
PATENT POSITION

For each of the devices described in this **SAFETY ALERT** there is a patent pending. **Triodyne Inc.** is developing a royalty and licensing program for manufacturers and users who require anti-hair entanglement devices in their drain systems. For licensing information please contact Peter J. Poczynok at Triodyne Inc., (847) 677-4730, ext. 111.



(a) Knotting Mode *(b) Wrapping Mode*

Figure 5 – Cantilevered Grating Elements



(a) Rectangular Array *(b) Circular Array* *(c) Domed Array*

Figure 6 – Cantilevered Grating Assemblies

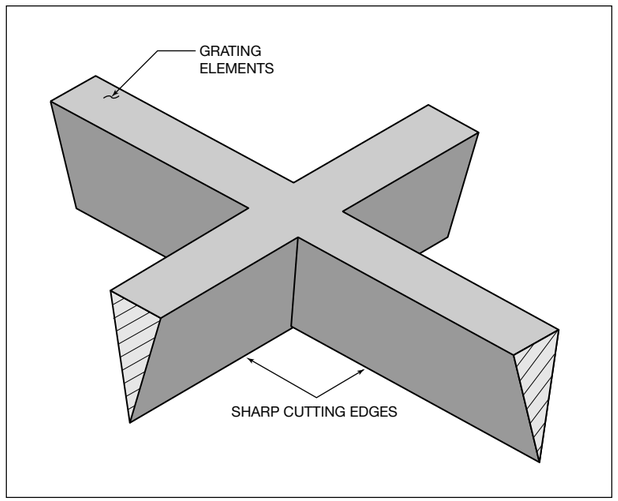


Figure 7 – Intersecting Sharp Edge Grating Elements

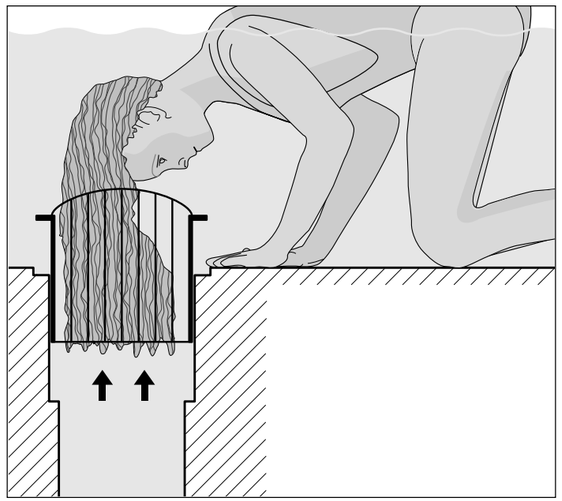


Figure 8 – Lifting An Unsecured Grating

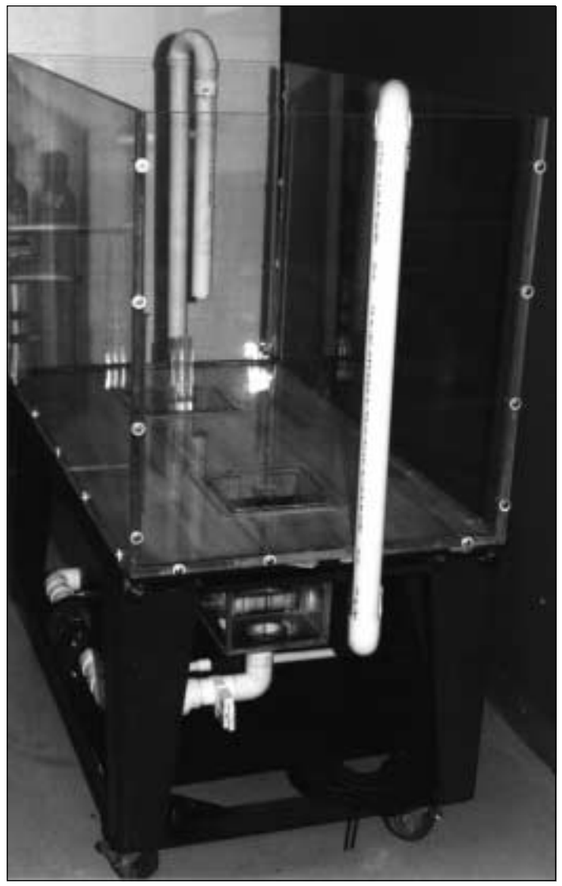


Figure 9 – Drainage Test Tank

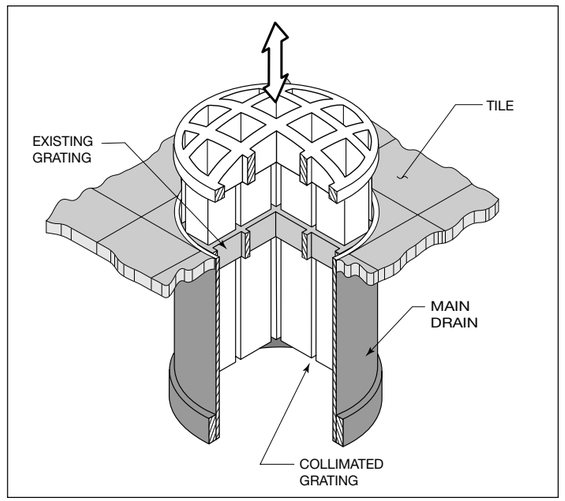


Figure 10 – Collimated Grating Over a Fixed Grating

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Illustrated and Produced by
Triodyne Graphic Communication Group