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SAFETY BRIEF

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Triodyne Inc.
Consulting Engineers and Scientists
5950 West Touhy Avenue Niles, IL 60648-4610 (708) 677-4730
FAX: (708) 647-2047

Deadman Controls on Lawn Mowers and Snowblowers

By Ralph L. Barnett[1] and Dennis B. Brickman[2]

Abstract

By exercising their rights under the Freedom of Information Act, the authors obtained the Consumer Product Safety Commission data on injuries sustained with lawn mowers and snowblowers equipped with deadman controls. The associated failure modes and effects verify the predictions contained in the literature. All of the failure modes involve ergonomic considerations. "Bypass" incidents are characterized using the Compatibility Hypothesis and "reliability" accidents are explored with the Dependency Hypothesis. There is also a discussion of the zero mechanical state (ZMS) concept and its relationship with the current approach to lawn mower and snowblower maintenance.

I. INTRODUCTION

Deadman controls were first introduced into locomotives to prevent runaway trains occasioned by the death or incapacitation of motormen. This safety concept now appears in such diverse places as forklift trucks, inching controls, and hand circular saws. Its use on outdoor power equipment has the potential to minimize blade or auger contact accidents by only allowing dangerous machine motions while the operator is located behind the appliance holding a spring-loaded control handle in operating position. Movement away from the operator station requires the release of the control handle which stops locomotion and blade or auger rotation.

An unusual sophistication was associated with the introduction of deadman controls on lawn mowers; the downside of the deadman control was studied simultaneously with its advantages.

Organizations such as the American National Standards Institute (ANSI), Consumers Union (CU), Consumer Product Safety Commission (CPSC), National Safety Council (NSC), and the Outdoor Power Equipment Institute (OPEI), together with the lawn mower manufacturers, participated in an elaborate multi-year study of the efficacy of deadman controls on lawn mowers. Detailed consideration was given to the cost penalty deriving both from the increased initial lawn mower cost, and the increased maintenance cost of the deadman control. Further, reliability of the candidate deadman devices was studied with special emphasis on blade stopping time. It should be noted that it is more difficult to stop a blade reliably in a short time than in a longer time. Finally, human factors investigations were directed toward the

[1]Professor, Mechanical and Aerospace Engineering, Illinois Institute of Technology, Chicago, Illinois

[2]Mechanical Engineer, Triodyne Inc., Niles, Illinois

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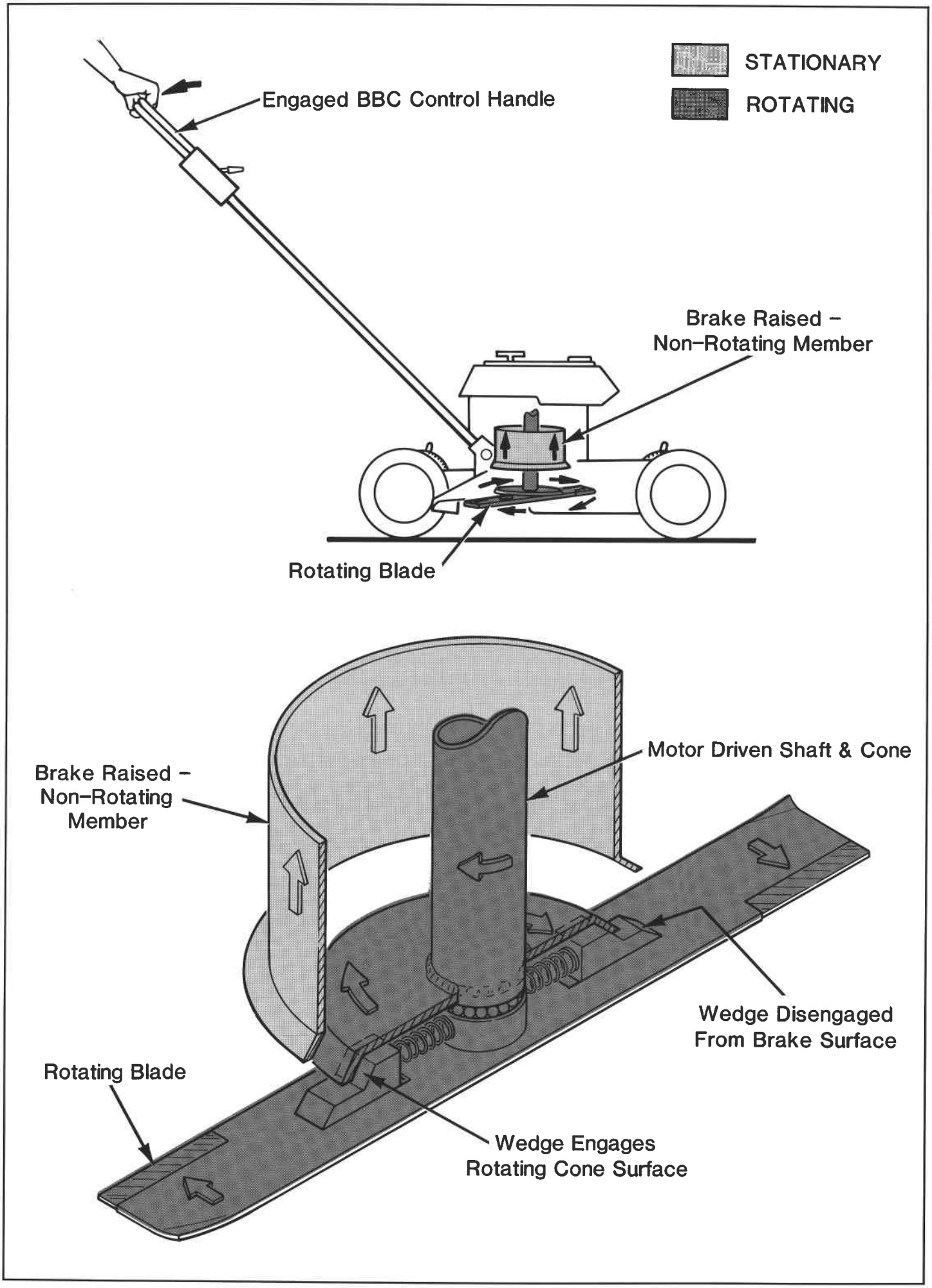
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ROTATING
Engaged BBC Control Handle
Brake Raised –
Non–Rotating Member
Rotating Blade
Brake Raised –
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Member
Motor Driven Shaft & Cone
Wedge Disengaged
From Brake Surface
Rotating Blade
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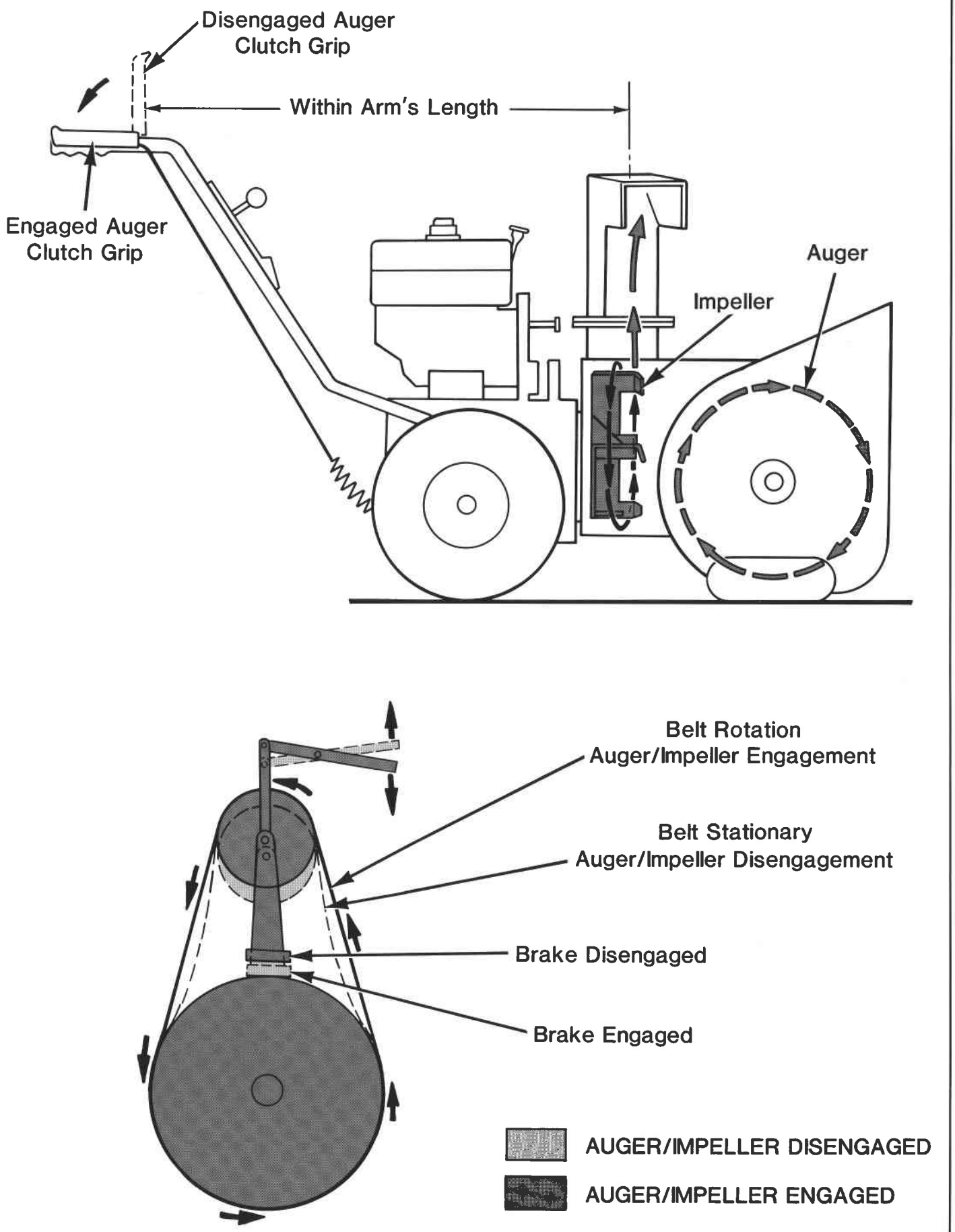
Disengaged Auger
Clutch Grip
Within Arm's Length
Engaged Auger
Clutch Grip
Auger
Impeller
Belt Rotation
Auger/Impeller Engagement
Belt Stationary
Auger/Impeller Disengagement
Brake Disengaged
Brake Engaged
AUGER/IMPELLER DISENGAGED
AUGER/IMPELLER ENGAGED

A. Tiedown Bypass of Deadman Control

1. Literature

a. Stanford Research Institute
April, 1975 [4]
"It should be pointed out that a totally non-defeatable deadman control does not presently exist, and one may not be developed in the foreseeable future. Therefore, it is possible that with the mower deadman defeated, grass catcher emptying, discharge chute clearing, and underdeck cleaning operations can be performed with the engine and blade running."

b. CPSC, May, 1977 [5]
"However, where the mower must be manually restarted, CU believed that the operator may be tempted to disable the deadman control in order to avoid the necessity for restarting the engine after releasing the deadman control (for example, by tying or taping the control in the actuated position). In order to discourage disabling of the deadman control, CU recommended two requirements applicable only to walk-behind mowers. First, the power source shut-off control must be inoperative unless the deadman control is released by the operator. This would discourage a relatively permanent disabling of the deadman control since the deadman control would have to be released in order to turn off the engine. CU also recommended that a means be provided to prevent operation of the blade if the wire or linkage to the deadman control were cut or disconnected. These two additional protective requirements to discourage disabling of the deadman control are referred to below as 'interlocks'."

"The Commission, however, believes that as a practical matter it would be very difficult and quite possibly expensive to design interlocks to discourage disabling of the deadman control that could not also be disabled by a user who was determined to do so. The Commission believes that a more effective approach would be to reduce the motivation for users to disable the deadman control by requiring that mowers with manual starting controls be 'easy' to restart if the power source stops when the deadman control is released." p. 23055

2. Reported Incidents:*

a. 5/18/85 MD
"Victim was mowing the grass in the back yard, reached down next to the edge of the mower to pick up a small rock and the blade struck his fingers. He had used a piece of rope to tie the safety handle back in place to keep the mower running when he stopped pushing the mower."

b. 5/15/86 NY
"A 23 year old male prisoner inserted his gloved right hand into the discharge area of a walk-behind gas operated lawn mower in order to clear it after it had clogged while cutting long wet grass in the prison yard. As the grass was removed, the mower blade rotated, amputating part of the victim's ring finger and crushing the index finger. An observer's report stated that the 'deadman' control was tied to the handle, circumventing the safety feature of stopping the engine when the handle is released."

c. 5/29/86 IL
"While using a one year old gasoline walk-behind power lawn mower to cut the grass in a friend's yard, a 16 year old boy lacerated the tip of his middle finger. He was attempting to reattach the grass bag to the lawn mower when his hand slipped into the mower's blade. He had previously wired the mower's dead man control down because the mower was difficult to restart when the engine was hot."

d. 5/23/86 MD
"The victim, a 62 year old male, was working on a 3 HP 22" cut gas powered rotary lawn mower. Blade was turning and motor was running. He laid his left hand on the housing while reaching for a screwdriver with the other. Left fingers turned up under the housing and were struck by the blade; left ring and little fingers amputated. Victim bypassed deadman control by securing the handle with wire."

e. 6/12/86 TX
"The victim is a 33 year old woman who was using a 1986 model walk-behind rotary lawn mower to cut thick wet grass in her back yard. She reached inside the grass discharge shield to unclog the grass and received a severe bruise and hematoma to her finger from the rotating blade. The blade safety control lever on this mower had been defeated."

f. 8/9/86 CT
"The victim, a 19 year old male, stated that he had suffered a hematoma to his right index finger due to accidental blade contact through the mower's discharge chute. He said he was removing clogged grass in the chute while the mower was running/blade turning. Victim further stated that the accident was his fault and was due to his 'misuse/negligence'. He said he intentionallly 'wired up the baler' so that the mowing session would not be interrupted. He was treated at the ER and was released."

g. 5/3/87 ID
"Victim removed grass catcher bag from mower, raised deflector on chute and attempted to clear wet grass from side discharge chute while blade was turning. The blade struck his first finger, causing a laceration to tip of finger. The victim had taped the deadman control handle to the main handle of mower causing the safety feature to be non-operable."

h. 2/7/83 WI
"A 78 year old male sustained amputation of 2 fingers while using an 8 HP gas powered snowblower. The deadman control had been taped in 'on' position. The victim slipped on the ice and his hand slid into the discharge chute and into the running fan blade."

*Narratives are quoted as they appear in the NEISS literature. The text has not been edited and incomplete sentences are unaltered.

B. Hold Down Bypass of Deadman Control

1. Literature

Ralph L. Barnett, July 24, 1986 [6]
"It's the nature of the activity. What happens is that once the task has been defined, that you want to put your hand and use it as a probe in front of the blade so that you can feel what the air flow is, then you should be given an opportunity to place yourself in the most advantageous position for your own personal balance, for your own personal control of this danger, which is simply a matter of staying away from the blade.

That once you have put a deadman switch on the machine, you have now constrained the operator to hold one hand in a fixed position and hold a lever down, and the range of possible positions that you can now take in front of the machine are highly restricted, and you will be restricted to – you know, if optimum positions exist for this particular kind of a misuse, you are denied those optimum positions because you have your hand restrained.

Furthermore, if you do not take – if you do not bend the handle, then when you hold the lever down and you put your hand in front, you will be denied visibility of the blade. Because you will not be able to see the blades while you are holding onto a straight handle.

You will be able to see it if you have the folded handle."

2. Reported Incidents:

a. 8/14/86 MA
"Victim was removing grass clippings from the discharge chute of a gas powered walk-behind rotary lawn mower. Mower was running since victim was holding deadman control with one hand and clearing chute with the other. Blade struck right index finger through chute."

b. 8/25/86 PA
"Victim using non-self propelled walk-behind mower missing kick guard and discharge chute, pulled mower backwards onto right foot while picking up stone lying to left of mower. Victim's right hand held engine control lever to prevent shutdown of engine. Mower blade set to highest setting."

c. 8/25/86 GA
"Victim was mowing with a 3 HP gas powered walk-behind lawn mower. He paused to remove a ladder which was in his path, holding the deadman control with his left hand. His right foot slid underneath the right side of mower housing. Blade cut through tennis shoe and nicked nail on his big toe."

d. 9/29/86 NY
"Victim was cutting grass for 2-1/2 hours in large backyard with a walk-behind gas powered rotary mower. Victim was wearing sneakers while cutting the lawn. The rear trailing shield had been broken about one year ago and never replaced. The mower is equipped with special control to stop mower blade from rotating when released. Victim pulled running walk-behind mower uphill backward and fell backward, not releasing special control to stop the blade. He pulled the mower back over his left great toe amputating it on contact with blade. He was hospitalized for 6 weeks."

e. 5/13/86 IA
"The 23 year old male victim was cutting grass in a trailer court. In this area there were several obstacles (pipes, wire, air conditioner) near one of the mobile homes. As he was cutting with his gas powered push mower he tripped backwards over a pipe. As he fell backwards, he pulled the mower over his left foot. He had a blade control on the handle. However, he didn't let go. The rotating blade cut through his tennis shoe and partially amputated his left big toe."

f. 8/5/86 NY
"Victim was cutting grass in a ditch with a gas powered walk-behind rotary lawn mower. The mower got hung up on a root and when she pulled it, it jumped up and fell on her left foot, partially amputating two toes. Mower was running and blade was turning; deadman control was engaged. Victim was wearing loafers."

g. 6/11/84 NY
"Victim was mowing 3 foot high grass in yard from top of hill downhill into ditch. As he pulled mower back uphill toward himself, he pulled rear of mower housing over sneaker (rear trailing shield broke off). Mower purchased in May, 1984."

h. 2/28/84 IL
"A 49 year old male suffered amputation injuries of his right middle and ring fingers after placing his right hand in the discharge chute of a one-stage electric snowblower. The unit had been clogged with snow and the victim placed his right hand in the chute while his left hand depressed the 'Deadman's' contro!. The victim does not expect to suffer any serious disabilities due to his injuries."

i. 1/31/84 CT
"A 40 year old male sustained lacerations to the tips of his left index and middle fingers when he attempted to unclog wet snow from the discharge chute of a snow thrower. The snowblower belonged to a friend and the victim intended to assist his friend in clearing the driveway. This was the first time the victim had used this particular snowblower, and it appears he failed to disengage the attachment clutch prior to attempting to unclog the discharge chute. Pins were required to reattach the tip of the bones in both fingers and victim was admitted to the hospital overnight."

j. 6/3/86 IL
"The victim, a 63 year old male, was adjusting the cable on a self propelled walk-behind rotary mower. His hand slipped and his finger struck the blade, breaking the finger. Victim was on his knees. The motor was running and the blade was turning. And a helper was holding the blade control on the handle. Victim no longer has mower."

C. Unreliability of Deadman Controls

1. Literature

a. CPSC November 2, 1978 [7]
"A number of mower manufacturers and a lawn mower trade association have stated their belief that a brake-clutch system would be unreliable and could present an increased safety hazard if it were to fail in such a way that the mower blade continued to turn when it was supposed to have stopped." p. 51039

b. Simplicity Manufacturing Company, July 26, 1977 [8]
"In addition to the increased cost, the mowers will be somewhat less convenient to use and will be subject to more complexities which could affect reliability."

c. The Toro Company, August 10, 1977 [9]
"It would be equally erroneous if the Commission were to bank solely on the blade-brake-clutch system to achieve deadman control. There has been too little consumer testing with either the engine kill or the blade-brake-clutch system to determine consumer usage or misusage patterns. There is also inadequate experience data available pertaining to blade-brake-clutch reliability under all operating conditions during the total working life of a mower."

d. Deere & Company, August 12, 1977 [10]
"We have a concern for the reliability characteristics of clutch-brake-mechanisms. Poor reliability could cause such systems to have a zero or negative benefit for safety. This reliability concern has been discussed repeatedly before the Commission, and for purpose of brevity it will not be reiterated here. However, we ask the Commission to be very careful in accepting certain claims of potential suppliers of the device. Years of design, test and manufacturing experience have taught us that seldom can a new 'shelf' component be adopted without a period of thorough evaluation followed by possible modification for improved function and/or reliability. Even with extensive engineering development work, clutch-brake reliability will be a continuing concern."

e. The Toro Company, March 31, 1978 [11]
"RESULTS:

Code #1
Three complete mowers submitted:
All three units were retired when the brake would not release at 0.0 hour, 0.5 hours, and 5.0 hours. The units could not be started as a direct result of these failures.

Code #2
Five complete mowers were tested:
All samples failed durability requirement.

Code #3
Two complete mowers submitted:
The clutch did not adequately transmit engine power to the blade. Clutch slips badly and will not cut 5" Bluegrass at 2" height of cut.

Code #4
Three early development test mowers and three early development complete mowers submitted:
Frequent clutch failures on the three early development units caused them to be judged unacceptable. One lab test unit had clutch failure in 5 minutes, when repaired it failed again in 2 minutes. One unit ran 1.6 hours on field test before clutch failure.

Code #5
One early development test mower:
The clutch bearing failed at 5 hours.

Code #6
Two complete units for concept evaluation:

1. First unit ran 13 hours before failure due to excessive clutch wear.

2. Second unit would not function at 0.0 hours because the brake would not release enough to allow the engine to turn the blade. The brake would kill the engine when the clutch was engaged."

f. FMC Corporation, April 11, 1978 [12]
"1. Comet Centrifugal clutch/brake assembly was tested at our Florida test site in late 1975 and early 1976. We experienced problems with the assembly after only 12 hours of testing. We discontinued the test shortly thereafter and sent the clutch/brake assembly back to Comet for their analysis. It is, of course, common knowledge that Comet is no longer pursuing any development of the clutch/brake assembly.

2. We tested another clutch/brake assembly in July of 1977. The manufacturer installed the assembly on one of our 22" walk behind mowers. We started testing and found the engagement time to be 7 seconds. The manufacturer thought the problem was due to residual mold release left on the clutch and suggested we run the unit under load for a few hours to burn off the mold release compound. We ran the clutch under load for 15 hours and found it made no difference; the engagement time was still 7 seconds.

3. During the last quarter of 1976 we tested another manufacturer's clutch/brake assembly. I thought at the time, and still do, that this design showed the most promise. It was very simple in design and had very few components. After only 240 clutching cycles, the unit failed to declutch."

g. Aircap Manufacturers, April 24, 1978 [13]
"To date we have not seen a blade clutch device that we could adopt with any assurance that we have solved a safety problem.

We have tested the two most commonly offered devices. For numerous reasons we could not use either one on our units. They simply do not take into account the total lack of maintenance generally experienced by users of our equipment."

h. OPEI, August 2, 1978 [14]
"Clearly, there is substantial doubt that the present vintage of clutch/brake designs will provide the level of safety all of us seek coupled with consumer satisfaction in terms of mower performance and product maintenance."

i. Worthington Industries, September 14, 1978 [15]
"To install our clutch on this mower required that we make alterations to both the engine and the lawn mower...We have complete confidence in our clutch, but we will not send this mower to Toro until we can assure ourselves that the engine and lawn mower modifications are reliable."

2. Reported Incidents:

a. 6/4/85 ID
"A 15 year old male sustained lacerations on his fingers when he contacted the moving blade of a rotary lawn mower while attempting to adjust the wheel height. The mower was equipped with a deadman control. The victim does not know if the control failed to shut off the engine or the blade was still turning from inertia when the accident occurred."

b. 5/26/86 VA
"A mower was being used for the first time this cutting season when the accident oc-

curred. The grass was long and wet, and the discharge chute became clogged. According to wife, the motor almost stalled and the victim released the deadman control and used his hand to clear the chute. She speculated that winter storage caused the 'kill' mechanism of the deadman control to rust and therefore malfunction. The deadman control on this model is designed to stop the engine from running."

c. 5/29/86 VA
"The sixteen year old male victim received ligament damage while operating a walk-behind push lawn mower on a bank. The victim slipped in wet grass and injured his wrist when he caught the lawn mower as it rolled back toward him. The engine blade stop device did not function because the cable from the handle to the engine was loose. Tightening the screw which held the cable to the engine corrected the problem."

d. 5/22/86 NY
"The 58 year old female victim was mowing her front yard. The grass was damp from previous rain. She was using a gas powered, rotary, walk-behind lawn mower with a bag on the side. She noticed that the grass wasn't getting into the bag, so she took the bag off after putting the mower in 'disengage' position, which she thought stopped the blade. Her left index finger was hit by the blade when she used it to clear the discharge chute, and her fingernail and part of the bone were torn off. A plastic surgeon at the local hospital repaired the wound and it is healing all right."

e. 00/00/00 CT
"Victim lost use of several fingers by reaching into deflector chute of snowblower to clear snow while the auger was disengaged."

f. 2/12/85 IN
"Snow began to pack at top of snowblower's chute. Operator released levers engaging the drives and pushed snow down with engine running. His fingers got stuck and cut."

g. 2/12/83 PA
"Victim thought he had disengaged the clutch to the discharge chute and he put his hand around the top inside of the discharge chute in an attempt to clear clogged snow when the turning blade cut his hand."

h. 3/29/84 NY
"Victim was snow blowing the parking lot of a commercial bank. The discharge chute became clogged with wet snow, so he disengaged auger (engine idling), put his hand approximately one foot down the chute, and contacted (impeller) blade."

i. 1/11/85 PA
"Victim was in the process of clearing, by hand, the snow from discharge chute and his finger was struck by the operating fan, the auger blade had been disengaged."

j. 2/16/83 NJ
"Victim thought that he fully disengaged the clutch to the discharge chute, and he put his hand in the discharge chute to clear out snow when he contacted the blade. The blade was turning at the time."

k. 2/19/82 NY
"A 50 year old male was removing snow from the sidewalk in front of a Masonic Temple with a walk-behind gasoline operated snowblower, when the chute clogged with heavy wet snow. After disengaging the impeller clutch he tried to remove the snow by inserting his glove right down the chute. His fingers contacted the moving impeller blade which fractured all the fingers, severed a tendon in the ring finger."

l. 2/11/82 MO
"A 34 year old male physician sustained compound fractures and lacerations to several of his fingers when he reached into the discharge chute of a snowblower he was using. He stated the motor was running, but the auger had stopped. He felt it was ok to place his fingers into the chute because he had released the collector/impeller drive which is located on the handle."

m. 2/21/82 NY
"A 64 year old accountant using a gasoline powered, walk-behind snowblower to remove snow from a stone walk near his home, had two fingers of his right hand torn off after he inserted his hand into the discharge chute to remove packed snow which had jammed the impeller blade. The impeller blade moved and hit the victim's fingers although the auger clutch was disengaged and the motor had been left running in 'N'."

n. 12/16/81 NY
"Victim's wife states victim was clearing clogged chute of 2 stage snowblower. He had disengaged lever to stop impeller blade (motor still running). Lever slipped and reengaged while victim had hand down discharge chute. Right hand contacted impeller and victim lost tip of right ring finger."

o. 12/28/81 MA
"Victim plowing driveway with 6 inches of wet snow (still snowing) when impeller blade stuck with wet heavy snow. Victim shut off impeller to remove snow from discharge chute with gloved right hand. As snow freed, glove and right index finger pulled to contact moving impeller blade."

p. 4/6/82 NY
"Victim was plowing neighbor driveway when discharge chute jammed with wet snow. He kicked lever several times to disengage impeller. On third try, put gloved right hand down chute and contacted moving impeller blade. Ring finger tip amputated and big finger cut at first joint."

q. 4/6/82 NY
"Victim was clearing snow from discharge chute clogged with mixture of snow and black top soil. Victim turned off impeller control. Banged on chute and then reached down chute to clear. Gloved right hand contacted moving impeller blade cutting right hand index and middle fingers."

r. 2/28/84 IL
"In the midst of a snow storm victim was using snowblower to remove slushy snow. Snow built up into ice that clogged discharge chute. Victim used stick to remove accumulated ice. He misjudged distance down chute placing middle finger in contact with moving impeller blade. Has had trouble with deadman control."

s. 2/19/82 NY
"Victim does maintenance at apartment and was plowing sidewalk with management snowblower. A wood stick got stuck in impeller blade and victim stopped blower to remove stick (engine still running). He put hand down discharge chute and contacted impeller – left index finger fractured."

t. 3/4/85 WI
"An adult female suffered permanent injuries to the fingers of her right hand when attempting to clear the discharge chute on a walk-behind, gasoline powered, two-stage snowblower. The snowblower is a 1975 model equipped with a side mounted clutch lever for engaging/disengaging the auger. The incident was the first time the complainant had operated the machine."

u. 2/12/83 NJ
"This snowblower is equipped with a 'Deadmans Clutch' by which the blades stop turning and the engine keeps going."

D. Extended Blade Stopping Time

1. Literature

a. 1968 - 1984 Multiple Sources
Stopping time is defined as the elapsed time from the release of the deadman control to cessation of blade or auger rotation. For the lawn mower, the trade-off between increased safety and decreased reliability of short stopping times was actively debated and the resulting recommendations are summarized in Table 1.

b. Deere & Co., August 12, 1977 [10]
"From a practical standpoint, the Commission should recognize that manufacturers must design for something less than the five-second stopping time to accommodate the normal "scatter" expected in production mowers. Thus, such mowers are likely to approach an actual 3.5-second stop time. Similarly, to consistently comply with a three-second requirement it may be necessary to design for less than a two-second stop time. Beyond the question of need, the stringent nature of a three-second stop time requirement could have serious reliability implications."

c. CPSC, February 15, 1979 [21]
"Another comment stated that the Commission did not take into account the effects of normal product deterioration which could result in longer stopping times as the mower ages, and that a consumer would expect the blade to stop in 3 seconds and could be injured if he or she put a hand under the mower after 3 seconds when the blade had not stopped because of product deterioration. It would appear that this comment would support establishing even shorter stopping times and would apply also to any stopping time requirement. However, the Commission has no reason to believe that stopping times will lengthen appreciably as the product is subjected to reasonably foreseeable wear and tear. In addition, tests conducted by brake-clutch manufacturers indicate that there are devices available that will stop the blade within 3 seconds during the useful life of the mowers being tested." p. 10009

2. Reported Incidents:

a. 7/21/86 NY
"Victim was operating the walk-behind power lawn mower on an embankment. He was wearing tennis shoes at the time and the grass was wet with dew. The victim was pulling the mower backwards up the embankment in order to mow the grass on the hill. His foot slipped on the wet grass and it went under the mower (his foot travelled faster than the mower as he was sliding and it ended up under the mower as it slipped down the embankment). The engine shut off as he let go, but the blade kept on going long enough to cut off most of the toe-nail of the victim's right big toe. His wife took him to the hospital emergency room where they removed the rest of the toe nail. Then the victim returned home."

b. 8/8/85 NY
"Victim was operating lawn mower cutting grass 'hurrying up' to avoid possible rain. He stopped mower to adjust right wheel height to perform trimming of inclined lawn. He released 'dead man control' on handle to reset wheel position. The blade was slowing down, but not stopped as victim reached under mower housing with left hand. The blade still moving contracted victim's left index, middle, and ring fingers."

c. 4/20/86 MD
"This accident involved a gasoline powered, walk-behind propelled rotary lawn mower bought in 1984. Victim, 41 year old female, was mowing grass at her father's neighbor's home on a flat area. She had stopped mower, blade was still turning and engine running. She had bent over mower with her left hand on top and was attempting to unclog chute. Her left finger contacted a still-moving on top and her finger was burned by the hot belt."

d. 5/30/85 ID
"A 24 year old male sustained contusions on his toes when his foot slipped under his rotary lawn mower. The mower was equipped with a deadman control which stopped the engine and reduced the severity of the injury significantly."

e. 1/31/84 CT
"A 39 year old male sustained a laceration to the tip of his left middle finger when he placed his left hand into the discharge chute of a snowblower in order to unclog wet snow. The victim had been using the snowblower on the driveway of his residence and had just disengaged the auger control and released the interlock levers on the handles when the accident occurred."

f. 11/19/81 MN
"A 14 year old male lost the tip of his thumb and lacerated two fingers on his right hand when he attempted to clear snow from the discharge chute of an 8 HP, two-stage, walk behind snowblower. The accident occurred at dusk and the snow was slushy. The victim had placed his hand in the chute within seconds after disengaging the auger clutch."

TABLE 1
BLADE STOPPING TIME RECOMMENDATIONS

1.	1968	15	Seconds	ANSI B71.1-1968 [16]
2.	1972	7	Seconds	ANSI B71.1-1972 [17]
3.	1973	7	Seconds	Federal Specification 00-M-1689, January 10, 1973 [18]
4.	1977	5-6	Seconds	Simplicity Manufacturing Co. July 26, 1977 [8]
5.	1977	1/4	Second	Leroy Coates, August 5, 1977 [19]
6.	1977	6	Seconds	Warner Electric Brake & Clutch Company, August 10, 1977 [20]
7.	1977	5	Seconds	Deere & Company, August 12, 1977 [10]
8.	1979	3	Seconds	CPCS Final Rule and Proposed Certification, February 15, 1979 [21-22]
9.	1980	7	Seconds	ANSI B71.1-1980 [23]
10.	1982	3	Seconds	CPSC Final Standard, effective June 30, 1982 [24]
11.	1984	7	Seconds	ANSI B71.1-1984 (Requirement applies only to reel mowers) [25]

E. Accidental Activation

Accidental start-up of lawn mowers has classically involved gasoline engine restart by rotating the blade manually or electric mower restart by bumping against a start control. Accidental activation of the deadman control adds a new start-up scenario to electric lawn mowers, gasoline powered lawn mowers with the BBC, and snowblowers. This problem has been addressed by manufacturers who include a zero mechanical state (ZMS) [26] admonition in their operator's manuals. The following instructions appear in manuals for lawn mowers and snowblowers equipped with deadman controls.

1. Literature

a. Snapper Power Equipment, October, 1982 [27]
"Before cleaning, repairing or inspecting, make certain blade and all moving parts have stopped. Disconnect and secure spark plug wire away from plug to prevent accidental starting."

b. The Toro Company, 1983 [28]
"Before the mower is serviced or adjusted, stop the engine and disconnect high tension wire from the spark plug. Keep the wire away from the plug to prevent the possibility of accidental starting."

c. Sensation Power Equipment, October, 1983 [29]
"When cleaning, repairing, or inspecting, make certain the blade and all moving parts have stopped. Disconnect the spark plug wire, and keep the wire away from the plug to prevent accidental starting."

d. Outboard Marine Corporation, 1984 [30]
"Safety Warning: To prevent starting of engine, disconnect spark plug lead and hook in spark plug lead notch, before cleaning underside of housing or clogged grass chute, or performing maintenance."

e. Outboard Marine Corporation, 1985 [31]
"Safety Warning: To prevent accidental starting of engine, disconnect spark plug wire before cleaning underside of housing or clogged grass chute, or performing maintenance."

f. Aircap Industries, Inc., January, 1986 [32]
"Stop the motor, wait for blade and all moving parts to stop, before cleaning, unclogging chute, removing grass catcher, repairing or inspecting the mower. Always disconnect power cord to prevent accidental starting."

g. Lawn Chief Manufacturing Company, October, 1986 [33]
"When cleaning, repairing or inspecting your mower make certain the blade and all moving parts have stopped. Disconnect the spark plug wire and keep it away from the plug to prevent accidental starting."

h. Ariens Company, July, 1985 [34]
"Stop engine, remove key, wait for moving parts to stop and remove wire from spark plug (keep wire away from spark plug to prevent accidental starting) before leaving operator's position for any reason such as unclogging auger/impeller housing, discharge chute, when making any repairs, adjustments, inspections or cleaning unit."

i. Honda Motor Company, 1985 [35]
"Shut off the engine before performing inspection and maintenance, and remove the spark plug wire from the plug so the engine cannot be started."

j. The Toro Company, 1985 [36]
"Before adjusting, cleaning, repairing and inspecting the snowthrower, and before unclogging the discharge chute, shut engine off and wait for all moving parts to stop. Also, pull high tension wire off spark plug and keep wire away from the plug to prevent accidental starting. Use a stick to remove obstructions."

k. Bolens Corporation, August, 1986 [37]
"When cleaning, repairing or inspecting make certain collector/impeller, and all moving parts have stopped. Disconnect spark plug wire and keep wire away from plug to prevent accidental starting."

2. Reported Incident:

2/2/85 NY
"Victim was plowing 2-3 inches of wet slushy snow from church sidewalk. He stopped the two-stage thrower to remove closed snow from discharge chute, while engine idled, he set impeller control to 'disengage'. As he reached into chute with his gloved hand, he believes his knee contacted the impeller control which moved to 'engage'. The impeller then contacted his hand."

IV. DISCUSSION OF RESULTS

Section A
Tie Down Bypass of Deadman Control

The Compatibility Hypothesis [38] is helpful in explaining why operators bypass deadman controls.

The Compatibility Hypothesis:
The larger the perceived improvement in utility compared to the perceived increase in risk, the greater will be the motivation to circumvent a machine's safeguarding system. Risk is taken as the probability of encountering a hazard already present on the machine.

There appear to be four popular reasons for tying down deadman controls on outdoor power equipment: the difficulty in restarting engines associated with the engine kill concept, hand fatigue in continually gripping the deadman control, excessive clutch/blade slipping for BBC systems, and clumsiness in maneuvering when constrained by the deadman control. An enormous amount of attention has been devoted to the problem of restarting engines including human factors considerations. It is both a common sense and scientific observation that a statistically significant number of people will perform tasks in the easiest manner [39].

We may now compare the increase in utility associated with tiedown bypass with the perceived increase in risk, i.e., probability of blade contact. Here, we observe that modern lawn mowers and snowblowers have caged the moving parts to the maximum extent possible, leaving only a few corridors through which blade contact can be accomplished. We note that the hazard locations are fixed, making it possible for operators to invoke the oldest safety control concept known to man, "keep away from the Tyrannosaurus Rex." Furthermore, when the deadman controls are bypassed, the machines are converted to the old, familiar, and trusted lawn mowers and snowblowers that have been traditionally used without deadman controls. In summary, we would expect the motivation to circumvent the deadman controls to be high since the increase in utility greatly outweighs the increase in risk. Indeed, the accumulating data supports this notion.

There are two safety implications related to the tie down bypass. The first obviously circumvents the advantages of the deadman control. The second is more insidious and involves a concept from the Dependency Hypothesis [40]:

The Dependency Hypothesis:
Every safety system gives rise to a statistically significant pattern of user dependence. This may also be stated in legal jargon: "User dependence on safety systems is foreseeable."

Operators develop a trained response when working on standardized machines; they expect lawn mowers and snowblowers to be safe once they release the deadman control. Clearly, when tied back, these controls cannot fulfil their mission and bypassed machines may injure operators who habitually depend on them.

Section B
Hold Down Bypass of Deadman Control

The deadman systems are not hostage controls, i.e., the compact geometry of lawn mowers and snowblowers enables operators to reach the various parts of the machines while maintaining one hand on the deadman control. There are a number of minor operational functions which users perceive can be performed without shutting down engine kill machines; for example, unclogging chutes, adjusting wheel heights, clearing the path in front of the mower of stones and debris, and removing obstacles such as chairs and toys. Furthermore, some troubleshooting activities on lawn mowers and snowblowers may require limited powered operation. All of these activities can be more easily performed by temporarily bypassing the deadman control by keeping one hand on the handle. Unfortunately, these misuse activities are exacerbated by the deadman controls which cause operators to assume clumsy positions where their balance and visibility are affected.

The CPSC data describes both advertent and inadvertent activities. The first of these involves deliberate temporary bypass situations of the type previously described. On the other hand, the data includes a number of slip and fall accidents and several cases where lawn mowers are pulled over the operator's feet. These are inadvertent scenarios. It may take more time to release a deadman control than an ordinary handle, and this can exacerbate blade contact injuries.

Sections C & D
Unreliability of Deadman Controls and Extended Stopping Time

According to the Dependency Hypothesis, a statistically significant number of operators will depend on the deadman controls to protect them against blade contact accidents when they leave the operator's station. If the deadman system fails to shut off the blade or if the blade drift time is too long, the deadman system "double-crosses" the operators and injuries result. This "false sense of security" was predicted by the industry and is demonstrated by the case histories described in sections C and D on deadman unreliability and extended stopping time respectively.

Section E
Accidental Startup

Accidental activation of lawn mowers and snowblowers is a classic misadventure that one would expect to be completely eliminated by a properly functioning deadman system. We note, however, that manufacturers do not rely on these controls; they insist on a zero mechanical state (ZMS) before any repairs are attempted. Furthermore, protection against the accidental activation of the deadman system is recommended by Consumers Union (CU) to wit [5]: "To prevent the unintentional starting of the blade when the 'deadman control' was contacted accidentally, CU recommended that it be necessary to operate at least one other control in addition to the deadman control in order to restart the blade." Indeed, many manufacturers incorporate a two-stage deadman control in their designs.

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What Is a Defect?

The definition of defective product in a state may be found in the case law of that state. In each issue we explore leading product liability case law from several states. Triodyne relies on the trial bar for selection of the cases cited.

IOWA

Aller v. Rodgers Machinery Manufacturing Co.

[268 N.W. 2d 830 (Iowa 1978)]

The plaintiff must prove the product is in a defective condition and that the defective condition makes the product unreasonably dangerous to the user or consumer. *Id.* at 834. Whether a defect is unreasonably dangerous or not is determined by application of a balancing test, in which the risk of using the product is balanced against its utility. *Id.* at 835. Product is defective if, as designed, manufactured, or assembled, it failed to perform reasonably, adequately, and safely in the normal anticipated and specified use to which the seller intended it to be put. *Id.* at 837. Whether a product is defective may depend upon when it was made. *Id.*

Kleve v. General Motors

[210 N.W.2d 568, 570-71 (Iowa 1973)]

In this case dealing with an alleged steering defect, the court held that the "unreasonably dangerous" element of a "defect" means a defect which was not contemplated by the user or consumer in the normal and innocent use of the product, citing comment (h) of § 402A.

Cooley v. Quick Supply Co.

[221 N.W.2d 763 (Iowa 1974)]

This case involved failure to warn of necessary danger due to certain conditions or types of use as a defect, although the product was intrinsically "flawless" (Dynamite fuse did not appear to be lit prior to explosion), citing § 298, comment (b) of the Restatement (Second) of Torts.

Hughes v. Magic Chef, Inc.

[288 N.W.2d 542 (Iowa 1980)]

In *Hughes v. Magic Chef, Inc.* the Supreme Court of Iowa held that:

(1) The plaintiff need not prove that the defect was not discoverable by ordinary inspection;

(2) "Misuse" was abandoned as an affirmative defense in favor of requiring plaintiff to plead and prove that the use was foreseeable; and

(3) "Assumption of Risk" is still a complete defense, but defendant must prove:

(a) plaintiff's subjective awareness of the risk, and

(b) plaintiff unreasonably proceeded to encounter the risk.

(Cases selected and text written by John Werner and Daniel J. Hanson, Grefe & Sidney, 2222 Grand Avenue, P. O. Box 10434, Des Moines, Iowa 50206.)

KANSAS

Lester v. Magic Chef, Inc.

[230 Kan. 643, 643 P.2d 353 (Kansas)]

Lester v. Magic Chef, Inc. was a strict liability case involving a young child who was severely burned by a gas stove. In that case, the Kansas Supreme Court held that Kansas followed the Consumer Expectation Test in determining whether a product was defective or not rather than the Risk Benefit Test.

The Consumer Expectation Test is simply defined as a product is defective if it is a condition not contemplated by and unreasonably dangerous to the user or consumer. The Risk Benefit Test is simply defined as a seller is presumed to have knowledge of all risks inherent in a product then the product is determined to be unreasonably dangerous based upon the consideration of a variety of factors including the use, influence and desirability of the product to the user and to the public, the likelihood of injury, the availability of substitute products and the manufacturers ability to eliminate or reduce the risks and avoid the danger of the product.

As stated above, in *Lester v. Magic Chef*, 230 Kan. 643, 643 P.2d 353, the Court opted the Consumer Expectations Test which is based upon, Commenti of § 402A of the Second Restatement of Law of Torts. There seems to be some question after that case, particularly in *Siruta v. Hesston Corp.*, 232 Kan. 654, 659 P.2d 799 (1983). In *Hesston*, the Court seemed to slightly lean toward a variation of the risk benefit theory but declined to explain the inconsistency with *Lester v. Magic Chef.*

However, any questions really should have been dispelled by the recent case of *Barnes v. Vega Industries*, 234 Kan. 1012, 676 P.2d 761 (1984), in which the Kansas Supreme Court held that it clearly adheres to the Consumer Expectations Test for defining a defect set forth in *Lester.*

(Cases selected and text written by Jon Blongewicz, Boddington & Brown, Minnesota Avenue at 7th Street, Suite 100, Kansas City, Kansas 66101.)

Editor: Paula Barnett
Illustrated and produced by Triodyne Graphic Communications Group.

TRIODYNE SAFETY PUBLICATIONS

Volume 1 No. 1
On Classification of Safeguard Devices (Part 1): Intrinsic Classification of Safeguarding Systems
by Ralph L. Barnett and Peter Barroso Jr.

Scientists and legislators set safeguarding standards for individual machines and specific processes. The courts, on the other hand, produce general rules which they apply to all machines thereafter. Since no *valid* general rules exist, the legal system is producing irrational tenets at odds with other intellectual disciplines.

Engineers can provide guidelines to help the courts make more reasonable decisions. The first step is to stop looking at safety devices as a homogeneous lump. Safety devices differ in the amount of safety that they provide and the amount of harm that they can do. This article presents a classification system which breaks down safety devices into mutually exclusive and jointly exhaustive catagories.

Volume 1 No. 2
On Classification of Safeguard Devices (Part II): Functional Hierarchy of Safeguarding Systems
by Ralph L. Barnett and Peter Barroso Jr.

Part II examines the relationships among individual safeguarding devices. The approach was to establish a pecking order which would allow safeguarding devices to be ranked according to the type of protection offered. However, important safety problems seemed to fall outside of its scope. For example, it did not explain why a knife is not unreasonably dangerous, or account for the very low injury frequency rate associated with the press brake compared to the mechanical punch press.

Proper account of a system's safety profile requires the introduction of a category which deals with those safety characteristics inherent in a system. These characteristics, which include simplicity, obviousness, slow motion, and wisdespread user training, are ranked under Zero Order Systems in the function hierarchy of safety devices and concepts.

Volume 1 No. 3
Zero Obstruction Repair Overpass

Professor Ralph Barnett, his students, and Triodyne are introducing a new concept in highway construction which enables roadways to be repaired without interrupting normal traffic flow. The concept is called Z.O.R.O, Zero Obstructing Repair Overpass. Z.O.R.O. is a movable, prefabricated hill which cars drive over while construction proceeds underneath. Z.O.R.O.'s lightweight, resusable modular design incorporates techniques developed for military bridge construction.

Volume 1 No. 4
Philosophical Aspects of Dangerous Safety Systems
by Ralph L. Barnett and Beth A. Hamilton

One of the unfortunate trends developing in the product liability movement is the promotion of dangerous safeguarding devices. Such devices arise principally from insufficient research, judicial coercion, and liability proofing. The safety literature presents an unequivocal mandate against the use of safeguarding systems that sometimes present hazards themselves.

Volume 2 No. 1
On Safety Codes and Standards
by Ralph L. Barnett

This article posits that 1) compliance, or non-compliance, with safety codes is presently the only rational way to judge whether a design is safe or defective, and 2) safety codes cannot properly protect the public interest unless they define both lower and upper bounds, or limits, on the conduct of designers. Engineers are introduced to the doctrine of "rebuttable presumption" relative to safety standards. Further, a semantic problem concerning the use of the term "minimum safety standards" is addressed.

Volume 2 No. 2
Safety and Product Liability Considerations in Farm Machinery Equipment
Only Photocopies Available

In December 1982, the American Society of Agricultural Engineers gathered at the Palmer House in Chicago for its Winter Meeting, celebrating its 75th anniversary as an organization. The meeting consisted of a variety of educational seminars, forums, and presentations. Professor Ralph L. Barnett presented a seminar entitled "Product Liability Considerations in Designs."

In March, April and May 1983, *Implement and Tractor*, the farm and industrial equipment industry trade magazine, published a series of articles inspired by Professor Barnett's presentation. These articles are reprinted in this ***Safety Brief***.

Volume 2 No. 3
The Dependency Hypothesis (Part I)
by Ralph L. Barnett, Gene Litwin, and Peter Barroso Jr.

This article discusses the types of changes in the man/machine interface which accompany the incorporation of safety systems into a machine. Safety systems introduced to meet narrowly defined safety objectives may give rise to broad secondary effects that subtly or profoundly influence the machine's overall safety and function. Designers and lawmakers alike must understand these secondary effects so they can weigh them against prevailing value systems to determine the overall desirability of safety devices. Some new criteria are described to aid in the evaluation of proposed safeguards.

Volume 2 No. 4
On the Safety of Motorcycle Side Stands
by Dror Kopernik

When a motorcycle is banked to the left with its kickstand down, or in the park position, the contact between the kickstand and the pavement can cause the driver to lose control. Some kickstand designs retract during such a turn without interfering with the driver's control. A reprint of Dror Kopernik's SAE Paper (No. 840905) is presented which explores the design parameters affecting kickstand retraction.

Drill Press Guards
by William G. Switalski and Ralph L. Barnett

An investigation into the safety of drilling machines has revealed a number of shortcomings of drill press safety guards. The results of Triodyne's research have been reported by the National Safety Council in *National Safety News*. The article is reprinted here. It is significant that the National Safety Council has withheld recommendation of the subject guards in all of their subsequent publications.

Volume 3 No. 1
The Dependency Hypothesis (Part II) — Expected Use
by Ralph L. Barnett, Gene D. Litwin, and Peter Barroso Jr.

Safeguarding systems may be introduced to perform specific safety tasks, to comply with some code or standard, or to liability-proof a machine.

Whatever the case, the device itself may be perceived to define a safety function and users will expect the device to perform that function. Moreover, one may argue, users have a right to such expectations.

Volume 3 No. 2
Safety Hierarchy
by Ralph L. Barnett and Dennis Brickman

Outside of the judicial oath, the most popular litany heard in a product liability trial is "the safety hierarchy." It is associated with a number of misconceptions which are explored in this paper. First, there is no such thing as **the** safety hierarchy; there are many hierarchies. Second, "it" is not a scientific law but rather a useful rule of thumb whose genesis is consensus. Finally, its complete form is broader than reported in any single reference.

Volume 3 No. 3
Trailer Hitches & Towbars
by William G. Switalski and Ralph L. Barnett

A survey of trailer hitch requirements in the 50 United States has highlighted problems of uniformity, communication, suitability, and design specificity.

Volume 3 No. 4
The Meat Grinder Safety Throat
by Ralph L. Barnett, Gene Litwin, and Gary M. Hutter

Every engineered system represents a tradeoff among at least three criteria: cost, safety, and function. For a meat grinder with a safety feed throat and stomper, common sense tells us that operator safety will increase as the throat diameter gets smaller and its length gets longer. It is just as apparent that the feed throat capacity will decrease accordingly. This paper quantifies the relationship among the throat parameters, the capacity, and the stomper force.

Volume 4 No. 1
Mechanical Power Presss Safety Bibliography
by Beth A. Hamilton, Joyce E. Courtois, and Cheryl Hansen

The safety literature on mechanical power presses (punch presses) is characterized by publications more practical than scholarly. It has not been subjected to the more exact bibliographic control of other technical literature, thereby inhibiting research on safety matters relating to power presses. The aim of this bibliography is to promote better control of, and to facilitate access to, the literature on mechanical power press safety.

Triodyne maintains a database on mechanical power press literature for scholarly purposes, with the intention of building the most comprehensive collection available on the subject. The scope of the bibliography is limited to coverage of the safety literature of mechanical power presses; pneumatically and hydraulically-powered press and press brake documents are excluded. Patents, manufacturers' literature, medical and legal literature, and student theses and dissertations have also been excluded. The time period covered is 1902 to Jan. 3, 1986.

Volume 4 No. 2
On Rubber Augers—Failure Modes and Effects
by Dennis Brickman and Ralph L. Barnett

Contrary to reported notions, the flexible flight auger gives rise to a new set of hazards and risks without fulfilling its promise of eleminating the amputation hazard. Increased jamming, elevated temperatures, grain damage, and rubber flight damage are among the failure modes observed.

Volume 4 No. 3
Mandatory Seat-Belt Usage Laws: Exemptions to the Rule
by Gary M. Hutter and Cheryl A. Hansen

The legislators of twenty-seven states have passed mandatory seat-belt usage laws, all of which provide a variety of exemptions to mandatory seat-belt usage. The categories and distribution of these exemptions provide an interesting examination of the perceived need and utility of vehicular seat-belts.

Volume 4 No. 4
A Proposed National Strategy for the Prevention of Severe Occupational Traumatic Injuries

The Association of Schools of Public Heatlh, under a cooperative agreement with the National Institute for Occupational Safety and Health (NIOSH), recently developed and published a proposal for minimizing traumatic injuries in the workplace. Contributing to this effort were over five hundred participants representing industry, government, business, trade unions, voluntary organizations, the professions, and academia. The resulting position paper, reprinted here, establishes a national strategy for the advancement of workplace safety.

Volume 5 No. 1
Principles of Human Safety
by Ralph L. Barnett and William G. Switalski

This paper describes selected concepts from safety and human factors engineering. Important philosophical tools that affect designs are summarized.

Volume 5 No. 2
Deadman Controls on Lawn Mowers and Snowblowers
by Ralph L. Barnett and Dennis B. Brickman

By exercising their rights under the Freedom of Information Act, the authors obtained the Consumer Product Safety Commission data on injuries sustained with lawn mowers and snowblowers equipped with deadman controls. The associated failure modes and effects verify the predictions contained in the literature. All of the failure modes involve ergonomic considerations. "Bypass" incidents are characterized using the Compatibility Hypothesis and "reliability" accidents are explored with the Dependency Hypothesis. There is also a discussion of the zero mechanical state (ZMS) concept and its relationship with the current approach to lawn mower and snowblower maintenance.

Power Punch Press Safety Package
Power Press Brake Safety Package

This package contains a series of safety posters, each as large as 30" x 40", in a reduced 8 1/2" x 11" format. The posters depict classic safety devices for the power punch press, or press brake, the areas where each is inapplicable, and the circumstances where it is unsafe.

Safety Registry: 1000

Access to the Triodyne $3,000,000 safety literature data base, representing almost two decades of intensive effort by engineers, scientists, and information scientists. It is comprised of over a thousand advanced bibliographies containing codes, standards, regulations, trade, and technical literature on topics ranging from aerial baskets through woodworking machinery.