TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA/TX-87/64+445-2F		

4. Title and Subtitle	5. Report Date
STUDY AND RECOMMENDATIONS FOR THE REDUCTION OF MOWER-THROWN-OBJECT ACCIDENTS	August 1986
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Kurt M. Marshek, Rowan E. DaSilva, and Srikanth M. Kannapan	Research Report 445-2F

9. Performing Organization Name and Address	10. Work Unit No.
Center for Transportation Research The University of Texas at Austin Austin, Texas 78712-1075	11. Contract or Grant No. Research Study 3-20-86-445
	13. Type of Report and Period Covered

12. Sponsoring Agency Name and Address	
Texas State Department of Highways and Public Transportation; Transportation Planning Division P. O. Box 5051 Austin, Texas 78763-5051	Final 14. Sponsoring Agency Code

15. Supplementary Notes

Study conducted in cooperation with the U. S. Department of Transportation, Federal Highway Administration

Research Study Title: "Mower-Thrown-Object Accidents"

16. Abstract

There has been a significant number of insurance claims against the Texas State Department of Highways and Public Transportation involving mower-thrown-object accidents. This report details the efforts madeeto reduce the number of mower-thrown-object accidents and discusses possible changes in mowing standards, available mowing equipment, and possible design modifications to mowers. Ideas and theories were tested and evaluated experimentally using a Terrain King TK 15-IV bat-wing mower.

The experiments were conducted to determine the relative safety of several types of safety devices. The experiments also served the purpose of determining where objects leave the mower.

From the experimental results several conclusions were made. Most of the objects exit the rear of the mower and safety devices such as chains and cables improve the safety of the mower.

Finally recommendations were made from the experiments and from the observations. The most important of these recommendations is that a canvas guard be added to the rear of the mower and a reduced mass cutting blade be further tested. In addition, the report discusses the background of mower-thrown-object accidents, blade design, possible application of alternative materials for blades, conclusions, and recommendations.

17. Key Words	18. Distribution Statement
mower, bat-wing mower, flex-wing mower, mower accidents, mower-thrown-objects (M.T.O.), experimental study, safety devices	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	164	

Form DOT F 1700.7 (8-69)

STUDY AND RECOMMENDATIONS FOR THE REDUCTION OF MOWER-THROWN-OBJECT ACCIDENTS

by

Kurt M. Marshek
Rowan E. DaSilva
Srikanth M. Kannapan

Research Report Number 445-2F

Mower-Thrown-Object Accidents
Research Project 3-20-86-445

conducted for

Texas State Department of Highways and
Public Transportation

in cooperation with the
U. S. Department of Transportation
Federal Highway Administration

by the

Center for Transportation Research
The University of Texas at Austin

August 1986

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

PREFACE

This is the second of two reports which describe work done on Project 445, "Mower-Thrown-0bject Accidents." This study was conducted at the Center for Transportation Research (CTR), The University of Texas at Austin, as part of a cooperative research program sponsored by the Texas State Department of Highways and Public Transportation and the Federal Highway Administration.

Many people have contributed their help toward the completion of this report. Thanks are extended to Dr. B. F. McCullough for his help and guidance and to all the CTR personnel, especially Lyn Gabbert, Monica Gonzalez, Loretta McFadden, Art Frakes, John Ermis, and Kitty Collins. Invaluable comments were provided by Quinner F. Williams, Bruce Barber and Gene Stabeno from the Texas State Department of Highways and Public Transportation and by Byron N. Lord from the Federal Highway Adminstration. Special thanks and acknowledgement is due to John R. Fisher, Chief Engineer, Terrain King, for his assistance and for providing a new Terrain King TK 15-IV mower for our mower-thrown-object experiments.

Thanks are due to Mr. Dale Stahlhut, Superintendent of Balcones Research Center, and Jodie Kaderka, Manager of the Service Center, for allowing the design group to conduct their testing at Balcones Research Center and assisting them with mower maintenance. We also acknowledge the students who have worked on and contributed to this report: Sao-Dung Lu, Tsen-loong Peng, Lei Rao, William Buhr, Seng Hark Gan, Dalton V. Souders, Kerry N. Allen, Timothy R. Rinkevich, David A. Williams, Aldo Bassignani, Gee Kwang Lim and Hugo Martinez. Finally we acknowledge the assistance of our distinguished colleague Professor L. F. Kreisle and his staff.

LIST OF REPORTS

Report No. 445-1, "An Experimental and Analytical Investigation of Mower-Thrown-Object Phenomena," by Rowan E. DaSilva, Kurt M. Marshek, and Srikanth M. Kannapan, presents data on mower thrown object phenomena. August 1986.

Report No. 445-2F, "Study and Recommendations for the Reduction of Mower-Thrown-Object Accidents," by Kurt M. Marshek, Rowan E. DaSilva, and Srikanth M. Kannapan, presents an experimental evaluation of mowers and mower-thrown-object accidents. August 1986.

ABSTRACT

There has been a significant number of insurance claims against the Texas State Department of Highways and Public Transportation involving mower-thrown-object accidents. This report details the efforts made to reduce the number of mower-thrown-object accidents and discusses possible changes in mowing standards, available mowing equipment, and possible design modifications to mowers. Ideas and theories were tested and evaluated experimentally using a Terrain King TK 15-IV bat-wing mower.

The experiments were conducted to determine the relative safety of several types of safety devices. The experiments also served the purpose of determining where objects leave the mower.

From the experimental results several conclusions were made. Most of the objects exit the rear of the mower and safety devices such as chains and cables improve the safety of the mower.

Finally recommendations were made from the experiments and from observations. The most important of these recommendations is that a canvas guard be added to the rear of the mower and a reduced mass cutting blade be further tested. In addition, the report discusses the background of mower thrown object accidents, blade design, possible application of alternative materials for blades, conclusions, and recommendations.

Key words: mower, bat-wing mower, flex-wing mower, mower accidents, mower-thrown-objects (M.T.O.), experimental study, safety devices.

SUMMARY

The main contributions of this report are results showing the effect of blade type, chains, cables, forward and backward motion, and object type on the problem of mower-thrown-object accidents. The results can be summarized as follows: (1) safety devices such as chains and cables significantly improve the safety of rotary mowers, (2) most objects for the mower tested exit from the rear of the mower, (3) a canvas guard added to the rear of the mower can reduce mower thrown object accidents, (4) the great majority of the mower thrown objects accidents are caused by rotary mowers, (5) backward mower motion is more dangerous than forward mower motion and (6) shorter and possibly lighter blades can reduce the range of mower-thrown-objects.

IMPLEMENTATION STATEMENT

The work carried out under this project provides highway maintenance and insurance personnel with information useful for assessing the effectiveness of various safety improvements on reducing mower thrown object accidents. Such information hopefully will lead to changes in mowing standards and mower specifications which will lead to improvements in mower performance and highway safety.

TABLE OF CONTENTS

CHAPTER 1. INTRODUCTION

The Texas State Department of Highways and Public Transportation (SDHPT) is responsible for the maintenance of Texas highways and adjoining right-of-ways. Their duties include mowing the grass on road medians and shoulders. With this maintenance there is an ever increasing problem with tractor mower-thrown-object (M.T.O.) accidents involving the public. The potential hazard of M.T.O. accidents has produced a significant and continuing problem for SDHPT. In an effort to curb mower-thrown-object accident frequency and severity, and improve public relations, the SDHPT has decided to investigate the mower-thrown-object phenomenon. Equipment and equipment modifications are thought to be in use in other states and countries which could significantly reduce M.T.O. accidents.

A previous report (Ref1) entitled "An Experimental and Analytical Investigation of Mower Thrown Object Phenomena" presents experimental and analytical results showing the effect of blade design parameters and thrown object physical variables.

This report presents a review of the literature associated with a variety of mower-thrown-object accidents; deals with the analysis of data from 1984 highway mower-thrown-object accident reports; presents ideas for mower design modifications; proposes an experimental set up and procedure as a standard test for evaluating mowers; and presents the results of extensive field tests with a bat-wing rotary mower.

BACKGROUND

The SDHPT employs various types of tractor mowers in their mowing operation. These include flail, sickle, and rotary bat-wing type mowers. Of the three, use of the rotary bat-wing mower constitutes the major cause of M.T.O. accidents. When the rotating blades of the mower hit debris or rocks, the debris or rock may be shot out from under the mower and into the path of passing motorists.

In response to an inquiry sent to various states, the SDHPT has received information regarding mower equipment, accident rates and remedial measures being implemented. In most cases the remedial measures have not been satisfactory.

In 1984, M.T.O. accidents accounted for approximately 20 percent of the 900 claims submitted to the SDHPT's insurance carrier. Lu, Peng and Rao (Ref 2) compiled a data base from the 111 accident claims filed in 1984. The data base comprised seven catagories: date of accident and time of accident, region of impact, direction of travel, type of mower, cost of damage and additional notes. According to the data base, 84.7 percent of all M.T.O. accidents reported involved tractor drawn rotary mowers. However, 57.7 percent of the 84.7 percent M.T.O. accidents involved the rotary bat-wing mower. Due to this high potential for serious fatal accidents the research efforts focused on improvements to the rotary bat-wing mower (Fig 1.1). The bat-wing mower is a device comprising three rotating blade assemblies. Each assembly has a cutting span of sixty inches and consists of two pivoted blades (Fig 1.2). The rotating blades may hit debris or rocks which are likely to be shot out from under the mower and into the path of passing motorists. At present, the safety features used to prevent mower thrown objects are stationary side skirts and double row 5/16 inch linked chains (see Fig 1.1). Even with these protective features, M.T.O. accidents still occur. Therefore, new ideas need to be explored in order to reduce M.T.O. accidents. The benefits of reducing M.T.O. accidents are:

1. The department will receive a significantly smaller number of M.T.O. accident claims and reduce the potential for serious accidents.

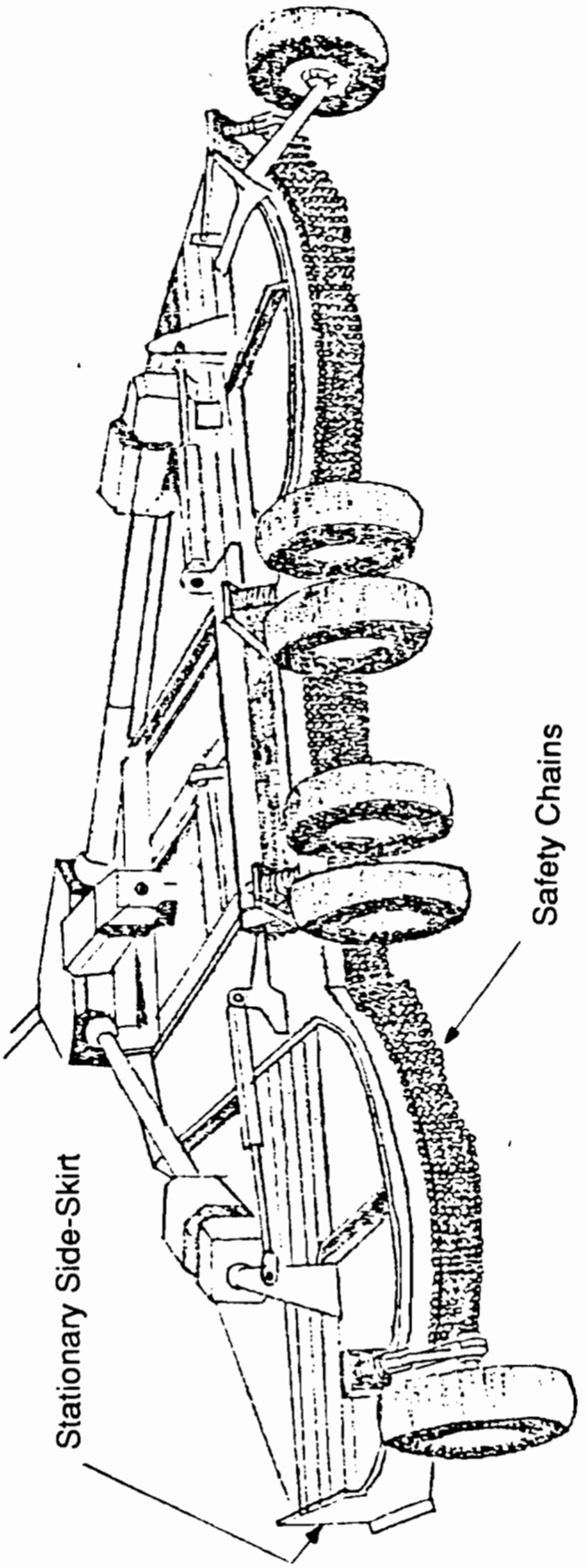


Fig 1.1. Bat-wing mower

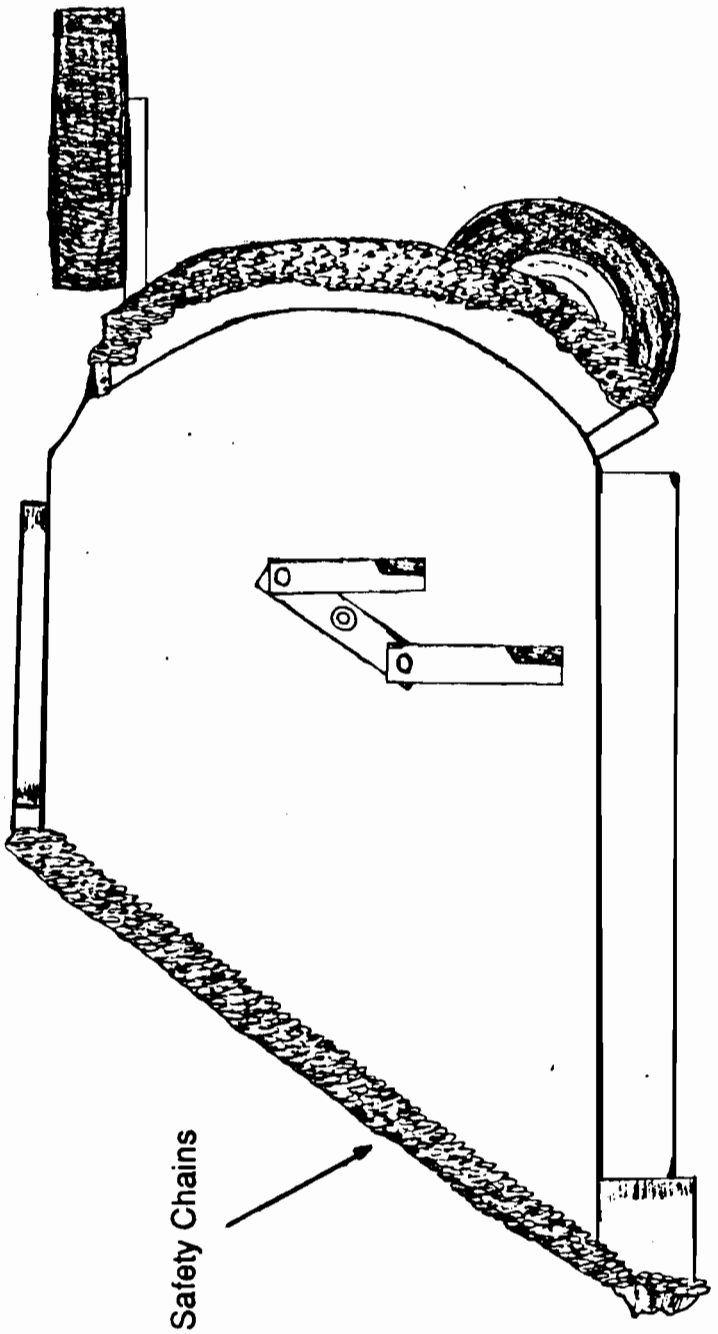


Fig 1.2. Assembly with break-away blades mounted on the mower

2. There will be a general improvement in public relations.
3. There will be an improvement in the safety of highway travel.

OBJECTIVES

The objectives of this research were to: (1) study existing equipment, mowing practices and accident data of the SDHPT followed by mowing practices and equipment of approximately 30 other states from available reports, (2) perform a computer literature and patent search, and visit mower manufacturers in Texas to review past and present developments in the reduction of M.T.O accidents, (3) form a database which would help in identifying specific patterns in causes of accidents, (4) recommend changes in equipment design, (5) evaluate the effectiveness of various design improvements on a bat-wing mower by performing field tests and studies and (6) identify possible remedial measures which would reduce the M.T.O. problem and explore the possibilities of implementing these solutions in the State of Texas.

SCOPE AND ORGANIZATION

Chapter 1 provides an introduction to this report.

Chapter 2 presents a literature review of papers, patents and reports related to mower-thrown-object (M.T.O) accidents.

Chapter 3 presents and analyses data obtained from accident reports.

Chapter 4 reviews the design of mowing equipment as it affects M.T.O.'s and presents design modification ideas for reduction of M.T.O. accidents.

Chapter 5 discusses the design of field experiments for the bat-wing rotary mower.

Chapter 6 presents the results of the field test results with the bat-wing rotary mower.

Chapter 7 presents conclusions and recommendations.

CHAPTER 2. LITERATURE REVIEW

A computer literature search was conducted, and product catalogs obtained from the SDHPT Procurement Office and The University of Texas Library were consulted. A list of tractor-mower-vendors were obtained so vendors could be contacted if further information was needed. This information helped determine what new or improved equipment exists that would help reduce M.T.O. accidents. In addition, information was gathered from other states and countries to see what was being done elsewhere about this problem.

BACKGROUND

Vegetation is established on the roadside to protect roads from soil erosion. This vegetation must be maintained on a regular basis. Mowing, brush control, and weed control are important aspects in the control of roadside vegetation. Mowing standards provide for nesting wildlife and for natural blending of the roadside with adjacent terrain (Ref 3).

The mowers used by most state highway departments are the flail type and the rotary blade type. A few state highway departments own and operate the sicklebar type mowers. The number and type depends on the area being mowed. Flail mowers are used for mowing shoulders, on slopes, medians and near guardrails and other locations of high risk. The sicklebar causes no problem at all with thrown objects but is easily plugged by grass and is frequently under repair due to the high number of moving parts. Hence this mower is reported as being the least desirable of all (Ref 4).

The flail type mower has been extensively used since the 1950's because of its simplicity and freedom from blockages. The principle of operation is that the blades strike the stem of the plants at such a high velocity that the inertial forces of the plants, as they resist rapid acceleration, provide sufficient resistance for the blade to generate stresses high enough to cause failure, long before the material reaches the blade velocity. The impulse transmitted during the cutting process results in a high velocity being imparted to the free materials. This velocity is further augmented by continuing contact with the high velocity blade and associated parts (Ref 5). The flail type is the safest mower from a M.T.O. accident standpoint, but experience with this mower has not shown it to be effective in cutting taller grasses. Due to a large number of moving parts, flail mowers are known to require constant maintenance (Ref 4 and 6). Furthermore, compared with the rotary type, flail mowers have higher acquistion and parts costs (Ref 4). The vertical flail action deflects debris downwards rather than outwards, making the flail mower safe when compared to the rotary type (see Fig 2.1 and Ref 7). Most flail mowers have a full length steel roller mounted at the rear which follows the ground contour and provides a solid barrier against mower thrown objects.

The rotary blade type is by far the most popular. However it is also characterized as having the highest M.T.O. accident rate. In this type, the rotating bar blade cuts groups of plant stems like grass and hay on a plane perpendicular to the fiber direction. The reasons for the popularity of the rotary mower are that it is the only mower that comes close to good performance over a broad spectrum of lawn conditions, has high production rates and the least maintenance and downtime costs (Ref 8).

Another development of significance is the rotary disc mower. The mower was developed in Europe but was not introduced in the U.S. until a few years ago. The promising aspect of this mower is the speed with which one can mow in almost any weather condition. VICON, a manufacturer of this

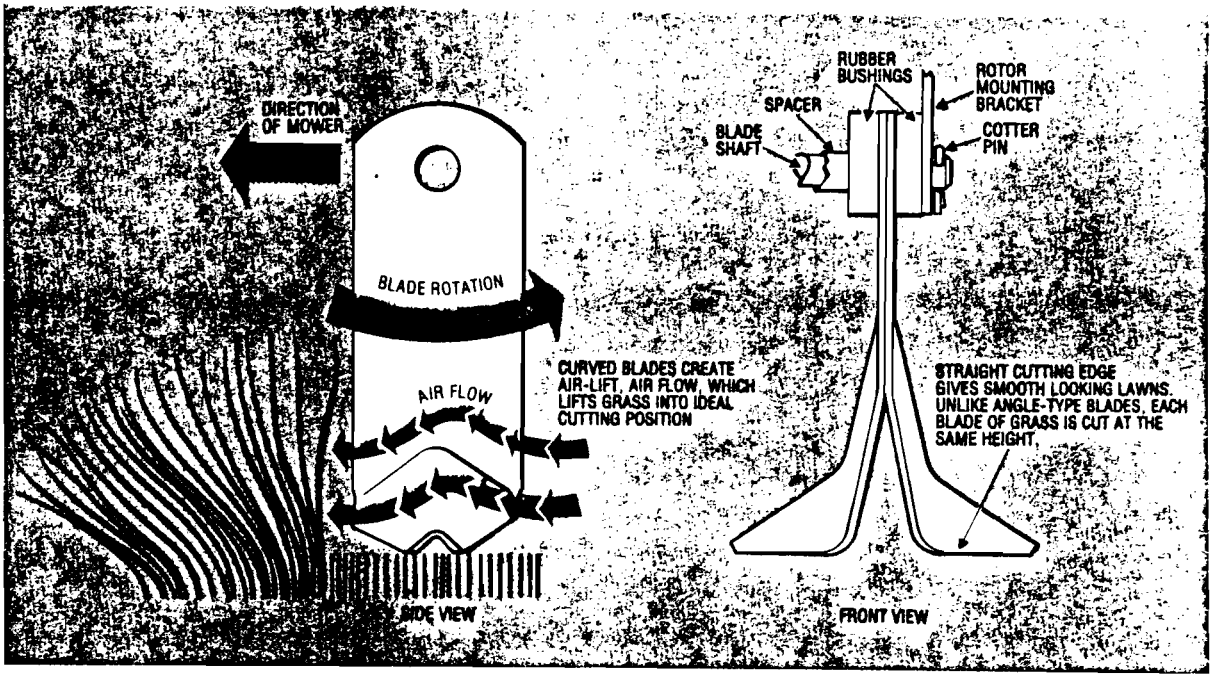


Fig 2.1. Woods self-cleaning air-lift blades for flail mowing (Ref 7)

machine uses a series of 3 to 6 triangular discs with three knives on every disc (see Fig 2.2 and Ref 9). The discs are arranged in contra rotating pairs with blade speeds of 3000 rpm (see Fig 2.3 and Ref9). If the cutter bar strikes an obstacle, it swings backwards automatically. The manufacturer of the above mower claims the mower is capable of speeds up to 8 mph. The State of Minnesota, which uses such a mower, reports that productivity of the rotary disc mower has been observed to be higher than that of the rotary blade and flail mowers they are using. Additionally, maintenance costs for a rotary disc mower over a comparable sicklebar are reported to be at least 50 to 60 percent lower (Ref 3 and 10). Minnesota and Connecticut State Highway Departments are presently replacing their existing fleet of sicklebar mowers with the rotary disc type. Furthermore the Minnesota State Highway Department has informed one of the authors of this report that they have been able to achieve an average of 60 to 80 road miles of single cut mowing on a normal 8 hour day inclusive of breaks. Minnesota reports that M.T.O.'s are the worst with large diameter rotary mowers, less with flails and the least with the disc mowers (Ref 10).

There are a number of variations of the three basic mower types. Examples of these are the batwing and the boom type mowers. The batwing consists of three rotary blade mowers pulled behind a tractor. The boom type mowers, depending on the manufacturer, have either a reel type or a rotary type mower on the end of a long boom.

An extensive computer search for literature and patents yielded information on M.T.O.'s by domestic garden rotary lawn mowers. Due to the similarity between the larger batwing mowers and garden mowers, from a M.T.O. standpoint, the work done in this area by researchers and inventors in the past is discussed in this report. Broadly speaking the effort to reduce the M.T.O. frequency and severity involved either a modification in the blade or a provision of a suitable guard or a shield. The authors did not find any organization or agency that maintains records or other information on highway mowers. The various organizations that were contacted are listed in Appendix B. Significant information and data was obtained from brochures, manufacturer's catalogs and reports from other State Highway Departments (Ref 11 and 12).

PAPERS

The literature search yielded numerous articles and papers on domestic garden rotary power lawn mowers. Some of the more interesting ones are described briefly herein.

Richard Thorud details a program to develop a safer lawnmower, named the Guardian, by Toro Manufacturing Corp. (Ref 8). His effort was directed towards the rotary mower rather than the development of a new cutting concept, primarily because of the universal appeal of the rotary concept. The project began with a review of available data on lawnmower accidents. Three major categories of lawnmower accidents identified in his paper are as follows :

1. Injuries involving direct contact, mainly between the operator and the lawnmower .
2. Injuries to the operator from thrown objects.
3. Injuries to bystanders from thrown objects.

Mr. Thorud then proceeds to discuss three safety measures that are often proposed by a mower designer.

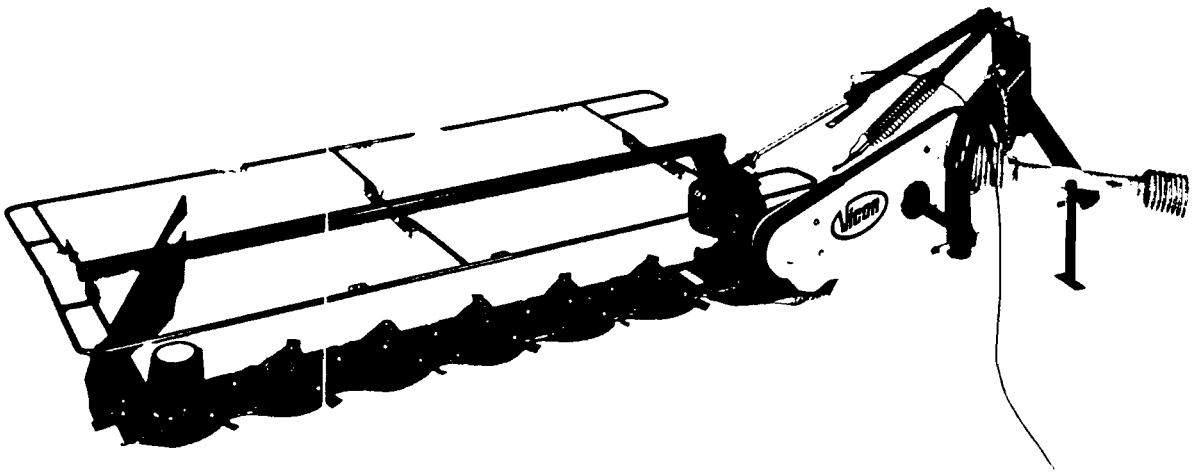


Fig 2.2. A 7-ft Vicon disc mower without the protective hood over the disc assembly (Ref 9)

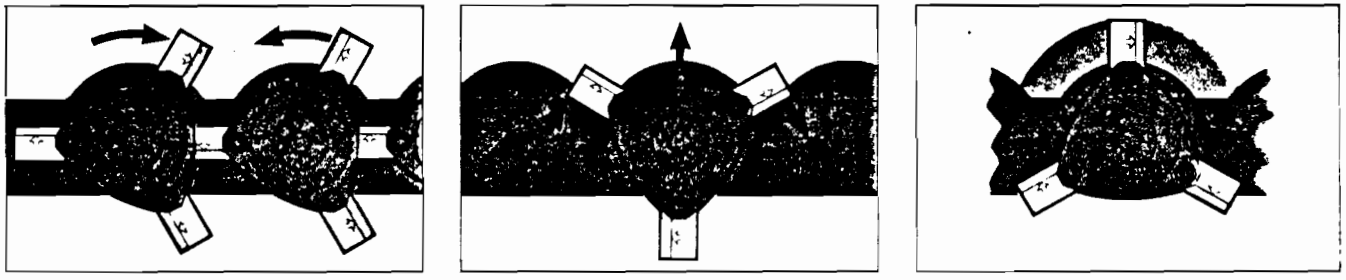


Fig 2.3. Vicon disc mower blade construction (Ref 9)
Triangular discs rotating at 3000 rpm, each mounted with three free swinging cutter-bars

1. Reduction in size or the elimination of the discharge port. However, this leads to windrowing, difficulty in collecting and disposing grass clippings and may even result in more serious accidents by random discharge.

2. Reduction in the tip speed of the cutter blade. This idea according to the author of the article is resisted by mower manufacturers as it results in mulched clippings building up on the inner walls and clogging the chamber. Moreover, an engine with increased horsepower would be needed to compensate for the torque lost by lowering the RPM.

$$HP = \frac{(RPM) \times 2 \times (\text{Foot-Pounds of Torque})}{33{,}000} \qquad (2.1)$$

Furthermore, a lower discharge velocity results in a less desirable dispersion of grass clippings and an increased tendency to plug the discharge port.

3. Another safety approach often proposed is to increase the amount of coverage around the blade. This would undoubtedly be safer, however, tests show that this type of enclosure becomes packed with clippings when cutting wet grass and the blade will have to be cleaned before continuing further.

Based on the preceding points, plans were formulated by Mr. Thorud to improve the design in these areas on their new lawn mower, the Guardian. The discharge port was modified to act as a baffle which deflects foreign objects and grass to the ground. The Guardian blade was designed to move large volumes of air at velocities sufficient to wipe the port clean. Random discharge is controlled by securing arc-shaped skirts to the bottom edge of the cutting chamber. The skirts also control airflow and reduce the buildup of wet grass, improve dispersion, and minimize port plugging. Another method used to control random discharge is to locate the edge of the Guardian cutting chamber well below the blade tips at most points, so that a randomly expelled object generally can assume a rising trajectory only after ricochetting off the ground, and the resulting injury will be less severe. A rear safety shield was incorporated to act as a solid steel barrier between the rear deck and the ground. The discharge area includes a safety interlock switch that stops the engine whenever the cover is opened.

The Guardian was then tested using the safety dispersion test developed by Toro Manufacturing Corp. In this test, the rotary mower is adjusted to a 1.5 in. cutting height and secured over an endless belt covered with artificial grass. Encircling the mower is an octagonal framework holding cardboard panels of double wall 350# cardboard. Test pieces are placed on the belt, which is actuated to convey the pieces beneath the mower. The test pieces are sucked up, struck and thrown by the rotary blade towards the cardboard panels. Damage to the panels is noted and used to study the discharge characteristics of the mower. Both the Guardian prototype and the Toro Whirlwind rotary (mower without modifications) were tested and the results indicated substantial safety improvement in all of the three major categories of lawnmower accidents. The Guardian was approximately equal to the Whirlwind in grasscutting abilities (Ref 8).

In another paper, McConnell, W., and Knapp, L., collected injury related data on accidents involving rotary power lawnmowers (Ref 13). The victims were interviewed for about 30 minutes by

the investigator and the accident scene photographed. Each accident was described in narrative form. The investigator listed at the end of the report, the role that (1) man, (2) machine and (3) environment played in the occurrence of the accident. McConnell and Knapp suggested the following for the reduction of rotary mower accident injuries:

1. An improved design that would decrease the velocity of the objects expelled through the discharge.
2. An improved design that would intercept the flight of an object thrown from the rotating blade of the mower.
3. Further education of the operator in safe mowing practices.
4. A safer method for the removal or attachment of mower blades.
5. An improved blade design to stop the blade automatically anytime the operator releases the handle or leaves the seat; for example, opening the door of a washing machine stops the agitator. Presently most mowers take between 60-90 seconds to stop after the mower has been turned off.

In another publication, Prof. William Chancellor presents a comprehensive study on the cutting of biological materials and specifically on the parameters of cutting performance, cutting mechanisms, cutting process variables and the cutting characteristics of various materials (Ref 5). This study serves as a good reference which can be used in mower blade design to compute the cutting power requirements.

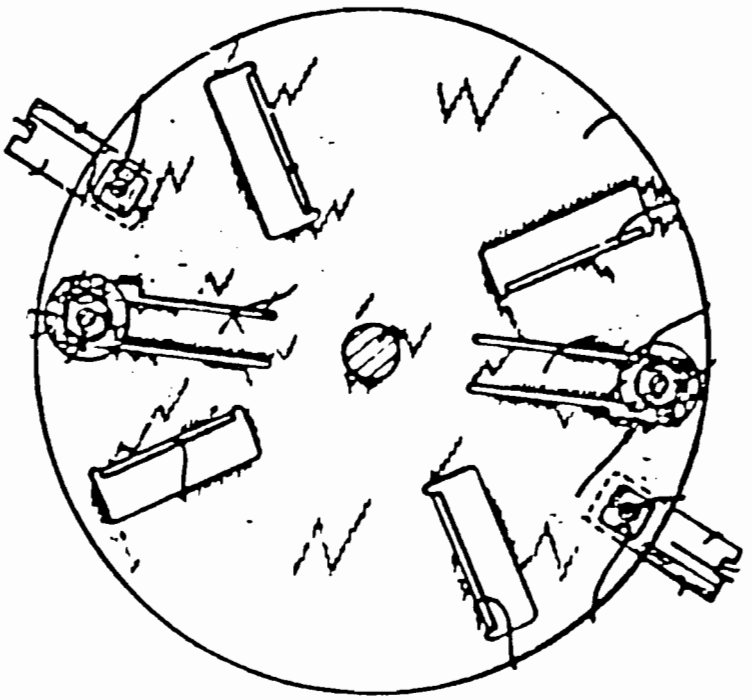
PATENTS

The Wood U.S. patent 3,690,051 dated Sept. 12, 1972, discloses a garden lawn mower blade construction comprising a disc having a plurality of radially disposed cutting blades pivoted thereto. The blades are positioned for cutting by centrifugal force but are pivotally retractable should they strike an obstruction. Novel means are provided to retain the blades in a retracted and non-cutting position after striking an obstruction in order to reduce the likelihood of serious injury to a user and of damage to the mower or blade (see Fig 2.4).

The Joseph Dell U.S. patent 4,369,618 dated Jan. 25, 1983, discloses a safety rotary lawnmower disc blade that uses a vacuum to draw flexible material to the cutting edge but will not suck up rigid materials. Both the vacuum generating element and the cutting edge are located on the same side of the disc (see Fig 2.5). The blade has four more or less tapered slots with their trailing edges sharpened to do the cutting. The narrow ends of the shots are raised to create a vacuum.

The Leonard Miskiewicz U.S. patent 3,570,225 dated Mar. 16, 1971, discloses a safety shield for a power driven lawn mower and control mechanism that is operatively interconnected between the lawnmower and the safety shield. The control mechanism is operative to lock the shield and mower in fixed positions relative to each other when the rear end of the mower is raised a predetermined distance above the ground, and is also operative to terminate electrical energy supplied to the power source driving the mower, when the mower is so raised (see Figs 2.6 and 2.7).

The Anthony Engler U.S. patent 3,577,871 dated May 11, 1971, discloses a chain curtain welded (or joined by some other means) to the mower housing. The curtain is made up of segments of a chain, and each segment is individually secured to the housing. A wire rope (or similar means) is passed through one of the lowermost links of each chain segment. This wire rope adds a certain



Blades are positioned for cutting by the centrifugal force

Blades retract on striking an object

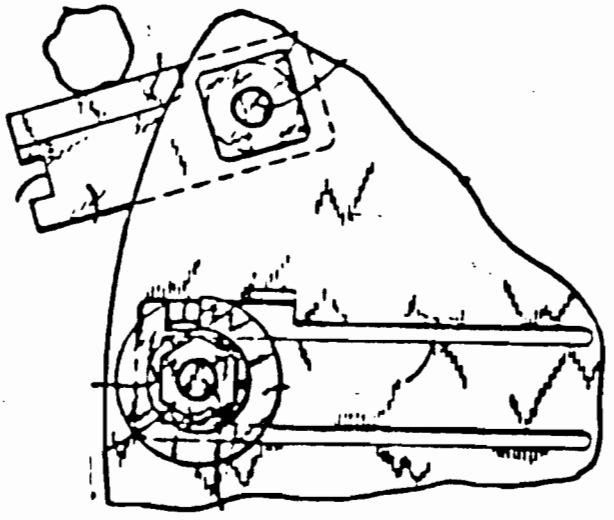


Fig 2.4. U. S. patent 3,690,051, showing radial retractable cutting blades mounted on a disc

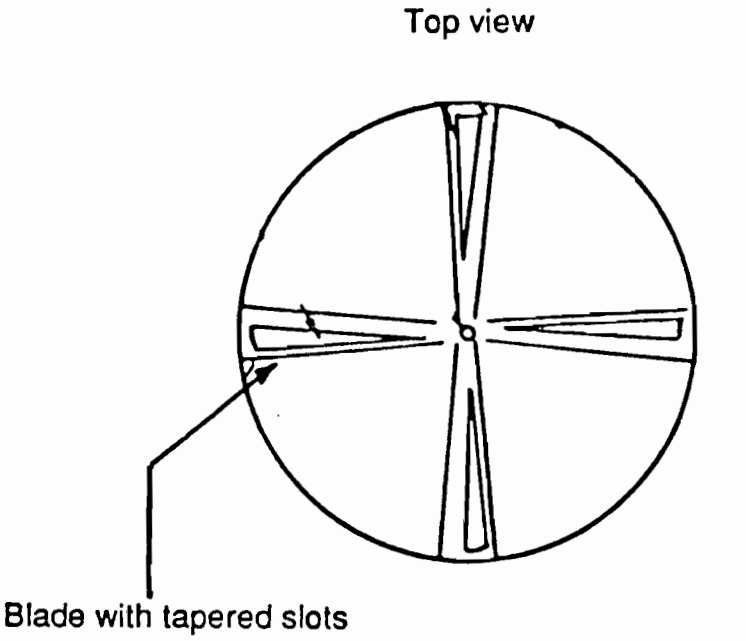


Fig 2.5. U. S. patent 4,639,618, Safety-Vac blade

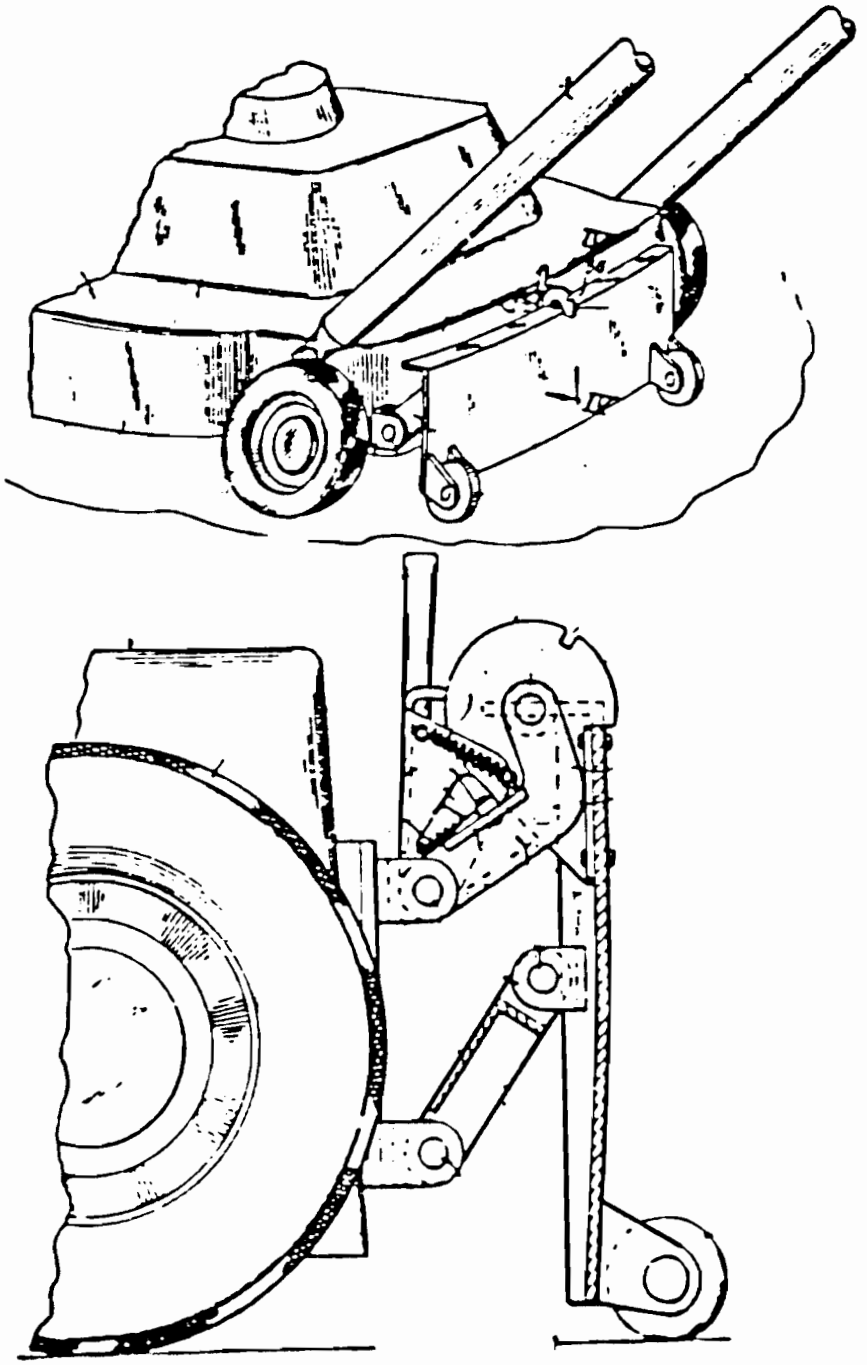


Fig 2.6. U. S. patent 3,570,225, showing a safety shield that can move up and down as the mower is raised or lowered.

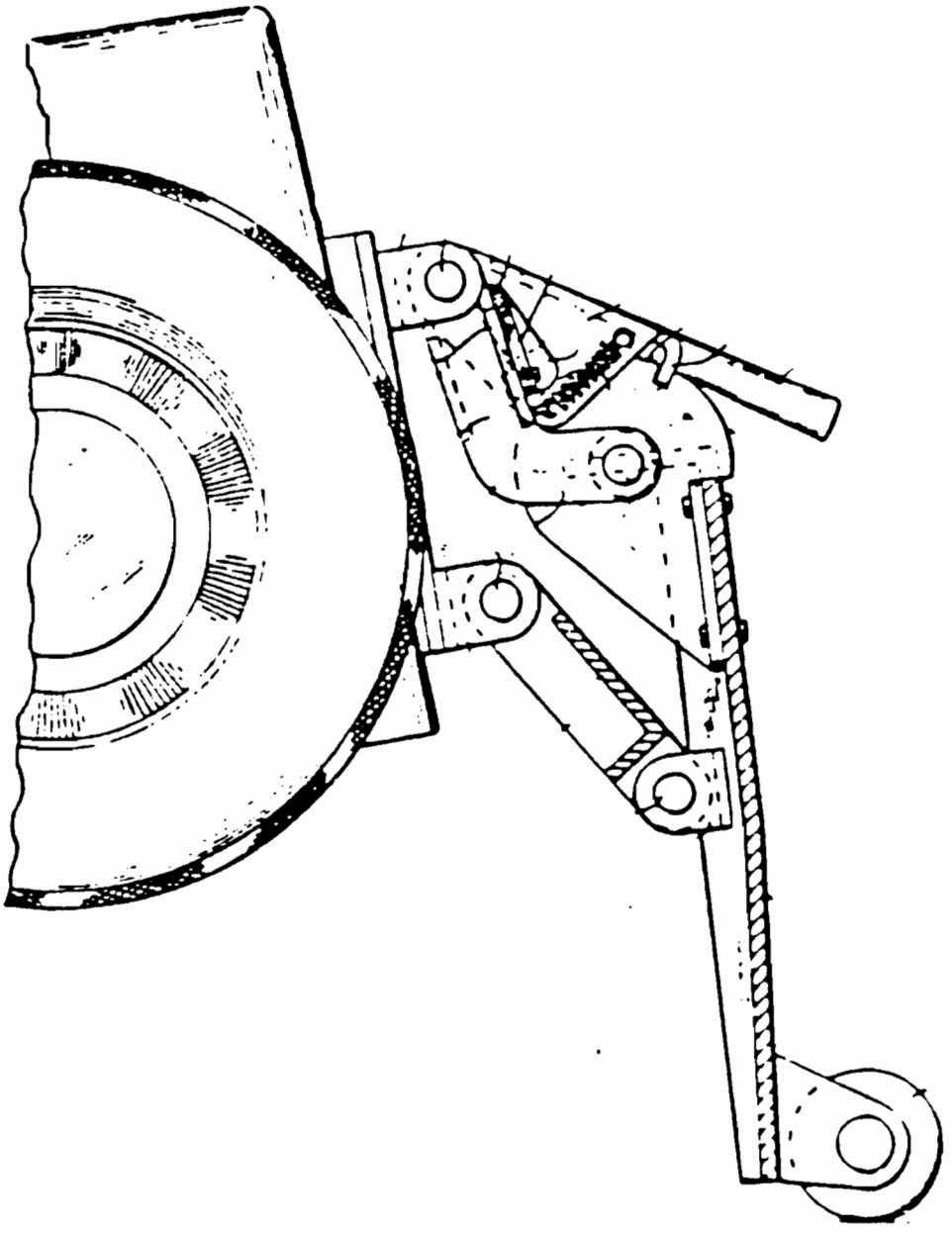


Fig 2.7. U. S. patent 3,570,225, showing the safety shield in its lowermost position

rigidity to the chain curtain and helps in stopping or restraining the M.T.O. in its flight by absorbing energy.

The D. Ramaker and R. Keller U.S. patent 3,297,513 dated Dec. 23, 1975, discloses a safety shield mounted between two laterally opposed support wheels of a rotary lawnmower to block any objects which may be hurled by the blade, and to prevent access to the operator's feet. The shield comprises a panel hung directly from the wheel axle so that vertically adjusting the housing relative to the ground does not alter the elevation of the lower edge of the panel relative to the ground (see Fig 2.8).

REPORTS

Mr. Quinner F. Williams, the Chief Engineer of the Insurance Division of SDHPT contacted various states for the steps that they have taken to control M.T.O. accidents. In response to their inquiry, SDHPT has obtained (from at least thirty different states) reports on mower equipment, accident rates and the steps they have taken to reduce the number of M.T.O. accidents (Ref 2). A brief description of the steps taken by these states to control M.T.O. accidents is documented in this report:

1. Restrict the Height of Cut

   The States have unanimoniously reported that an increase in the height of cut reduces the number of M.T.O. accidents. Some states have revised their specifications to limit the height of cut to 6 inches (Ref 14, 15, 16) while others are in the process of doing so. This has been cited as the single most important factor responsible for M.T.O. accidents. A popular recommended height is six inches.

2. Chain Guards

   Most states are now using chain guards to reduce the number and severity of accidents and acknowledge its effectiveness. The average thickness of the chain link is 1/4 inch and the guard may be either a single or double row chain guard. Some states have additionally reinforced the chain guard with rubber belting for added protection (see Fig 2.9 and Ref 2), (Ref 10, 15, 17, 18).

3. Equipment Choice

   Nearly all states have reported that flail mowers, though not as productive as the rotary mowers, have proved to be the safest, and recommend the use of flail mowers in areas of high potential for M.T.O. accidents; e.g., shoulders, medians and other areas. The State of New Jersey is replacing its entire fleet of rotary mowers with flail mowers (Ref 19). The State of Oregon reported that the maintenance operation cost of an 8 foot flail mower was less than that of an 8 foot rotary mower (Ref 20).

   The State of Minnesota reported that the use of rotary disc mowers resulted in a twofold increase in production over the sickle type with the M.T.O. problem still persisting (Ref 10). No state has reported if they are using the pivoted type blade which folds back on hitting an object or if they are using the dishpan type blade to tackle the problem (see Fig 2.10 and Ref 2). The

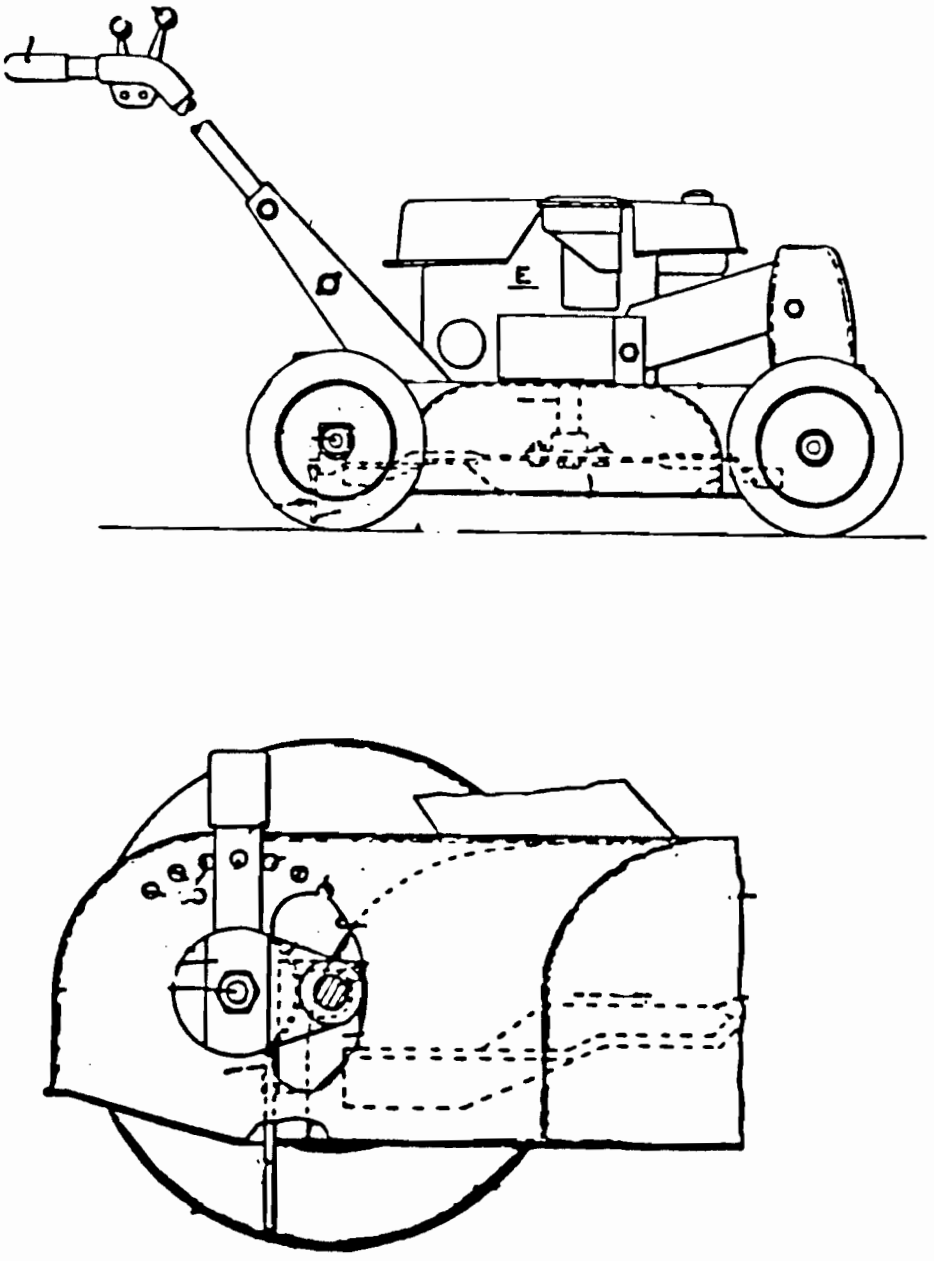


Fig 2.8. U. S. patent 3,297,513, shows a safety shield mounted between two laterally opposed wheels of a rotary mower

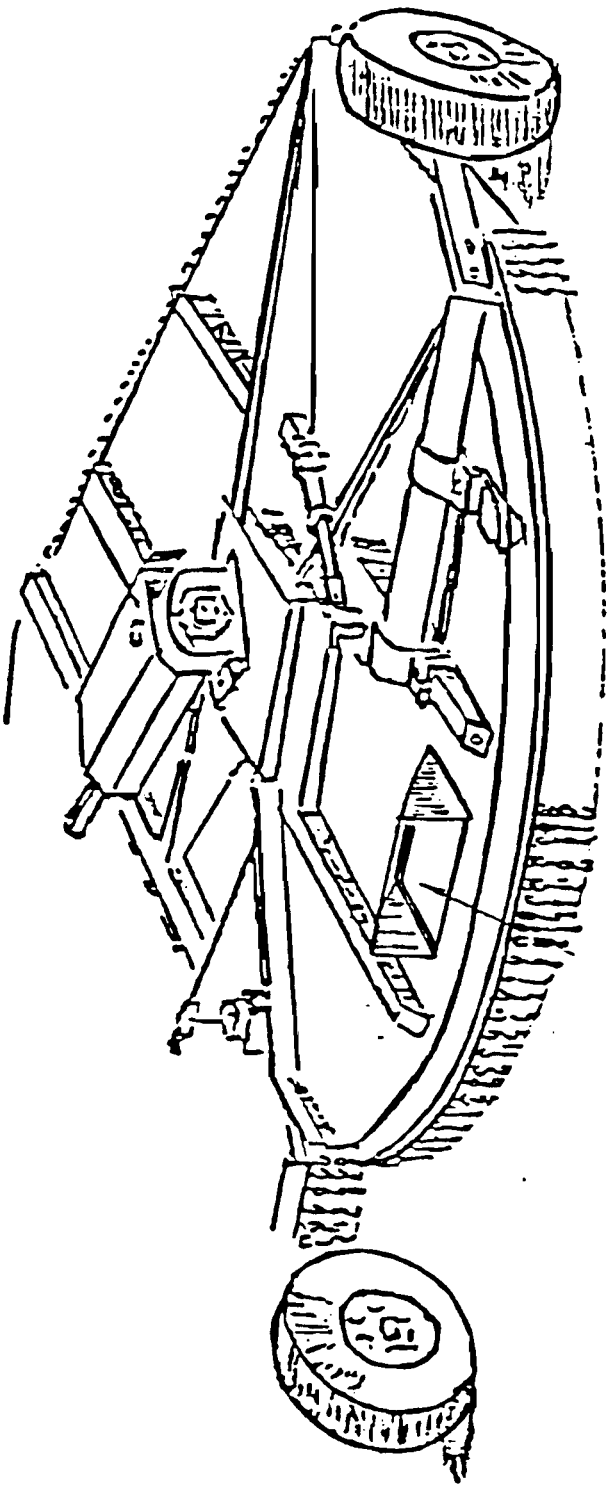


Fig 2.9. Mower with a chain guard (Ref 2)

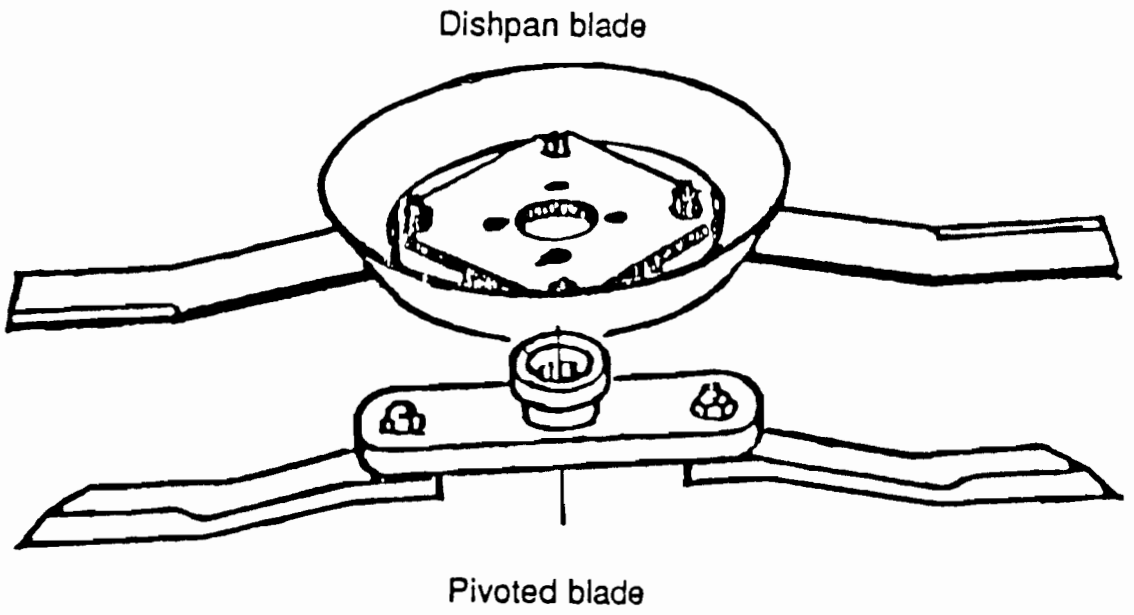


Fig 2.10. Dishpan and pivoted type blades (Ref 2)

manufacturers of the dishpan and pivoted blades claim that these blades help in reducing M.T.O. accidents. Another development that should help in reducing M.T.O. accidents is the automatic self-leveling adjustment on Rhino mowers which helps insure complete control over the cutter at all times. A parallel linkage connects the rear axle and the cutter tongue to raise and lower the cutter evenly. The cutter conveniently remains level no matter what cutting height is selected (see Fig 2.11 and Ref 2).

4. Chemical Control

Some states reported the use of herbicides and retarders as having produced fair results and are optimistic about this grass and weed control measure (Ref 4 and 10). The Oklahoma DOT in 1985 reported a cost of $ 8 to $ 9 per acre per treatment for chemical control and expects this cost to fall by more than 50 percent with time (Ref 21).

5. Operator Training

Some states mention enhanced operator training by their supervisors or foremen to create an awareness among the operators (Ref 5 and 22). In particular, the operators are instructed not to leave the shop without the chains or guards on the machine and to make sure that the height of cut is not reduced in the field. Operators are reminded that they must raise their mowers when passing over side roads, intersections, and driveways to reduce the danger of M.T.O. accidents (Ref 14). Mr. John Fisher, the chief engineer at Terrain King, informed the authors that in his opinion a high number of M.T.O. accidents occur when operators pass over side roads, intersections, and driveways without raising the mower. Some states report that operators were found to reduce the height of cut from that recommended.

6. Cleanup

Cleanup prior to commencement of mowing operations especially around high hazard areas like medians and shoulders is reported to be one of the measures undertaken to reduce M.T.O. accidents (Ref 14, 17, 23). Experienced operators familiar with the terrain were used whenever possible.

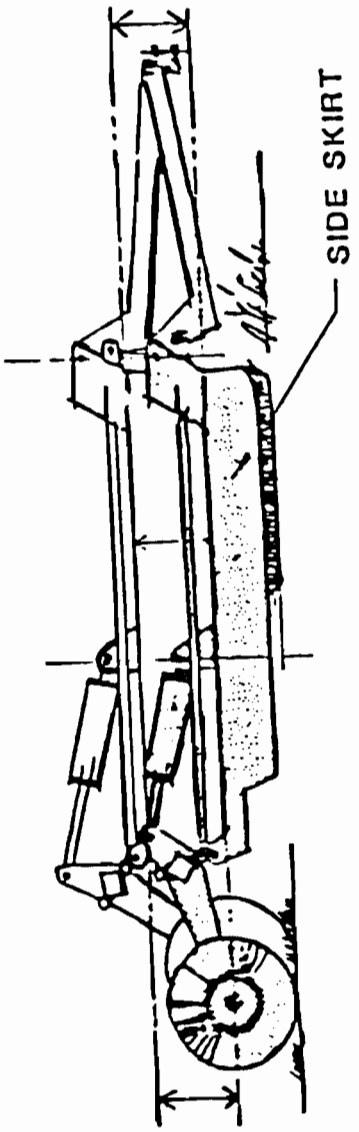


Fig 2.11. Rhino automatic self-levelling mechanism (Ref 2)

CHAPTER 3. DATA ANALYSIS

Almost 150 accident reports for 1984 (April-December) were obtained, entered into a data base and analyzed. The purpose of the data base analysis was to develop correlations between accidents and variables (such as time of day and mower-motorist orientation) and hopefully to provide insight into how and why M.T.O. accidents occur. Seven fields were set up: date and time of accident, region of impact, type of mower, cost of damage, direction of travel and additional notes. Many reports were incomplete and were left out. A total of 111 records were used to perform the final analyses.

ACCIDENT CLAIMS COSTS

A total of $20,488.57 was spent in payment of accident claims. The average cost per claim was $184.58. The largest amount paid was $2,335.14 for damages to a new recreational vehicle. A large number of claims were not followed up and no money was paid.

WEATHER CONDITIONS

The weather conditions did not appear to have any effect on the number of accidents. Since, the grass is not being mowed during inclement weather, almost all of the accidents occurred during dry, sunny, and clear days.

TIME OF DAY

The time of day does seem to have some correlation to the number of accidents, but its significance is questionable. A table of the number of accidents during each hour in the day is shown in Fig 3.1. The question is if any reduction in the number of accidents is due to fewer motorists or fewer mowers being operated. There were very few accidents occurring before 9 am. It is possible that there were fewer motorists in the morning. The number of accidents also fell during the noon hour and after 4 pm. This lull was probably due to a decrease in the number of mowers. The largest number of accidents occurred in the early afternoon. This was most likely to be due to a large number of both motorists and mowers.

TIME OF MONTH

There were not any accident reports for the months of January through March. The summer and fall months experienced the largest number of accidents, as shown in Fig 3.2. This is believed to be jointly due to the increased growth of grass and the increased number of motorists. Fewer accidents were reported in the winter and spring months, presumably due to a decrease in mowing activity.

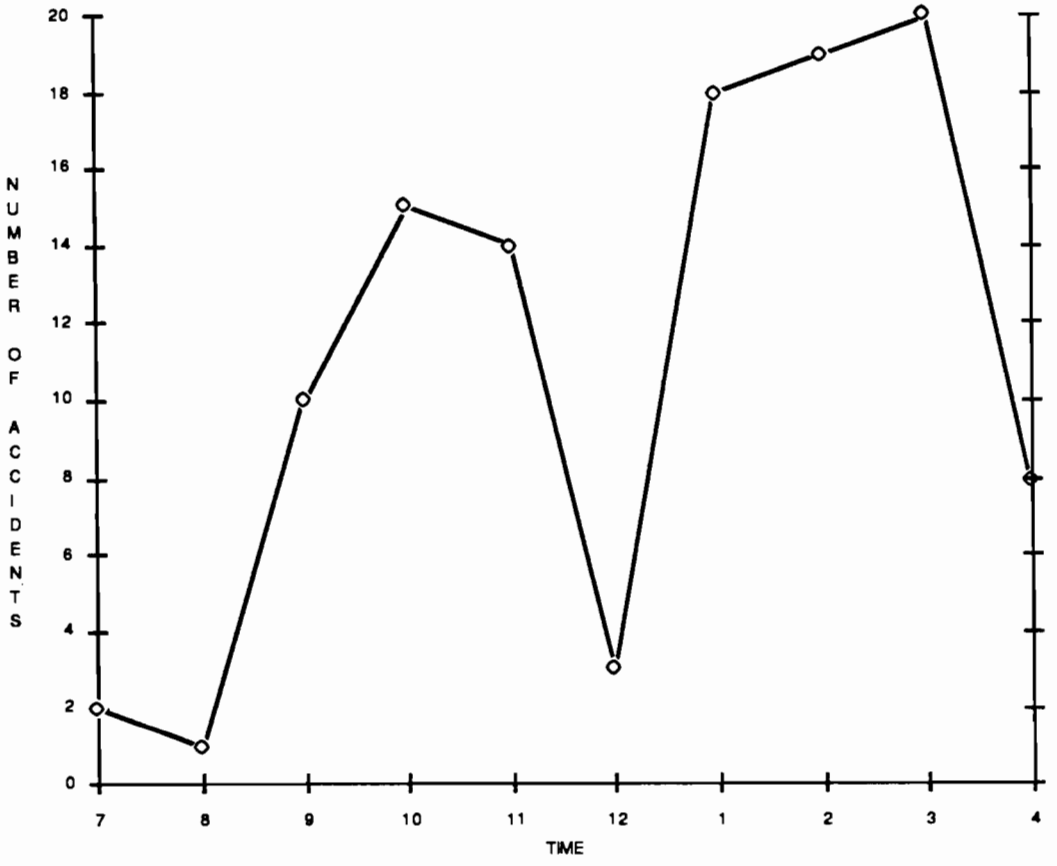


Fig 3.1. Number of accidents vs. time of day

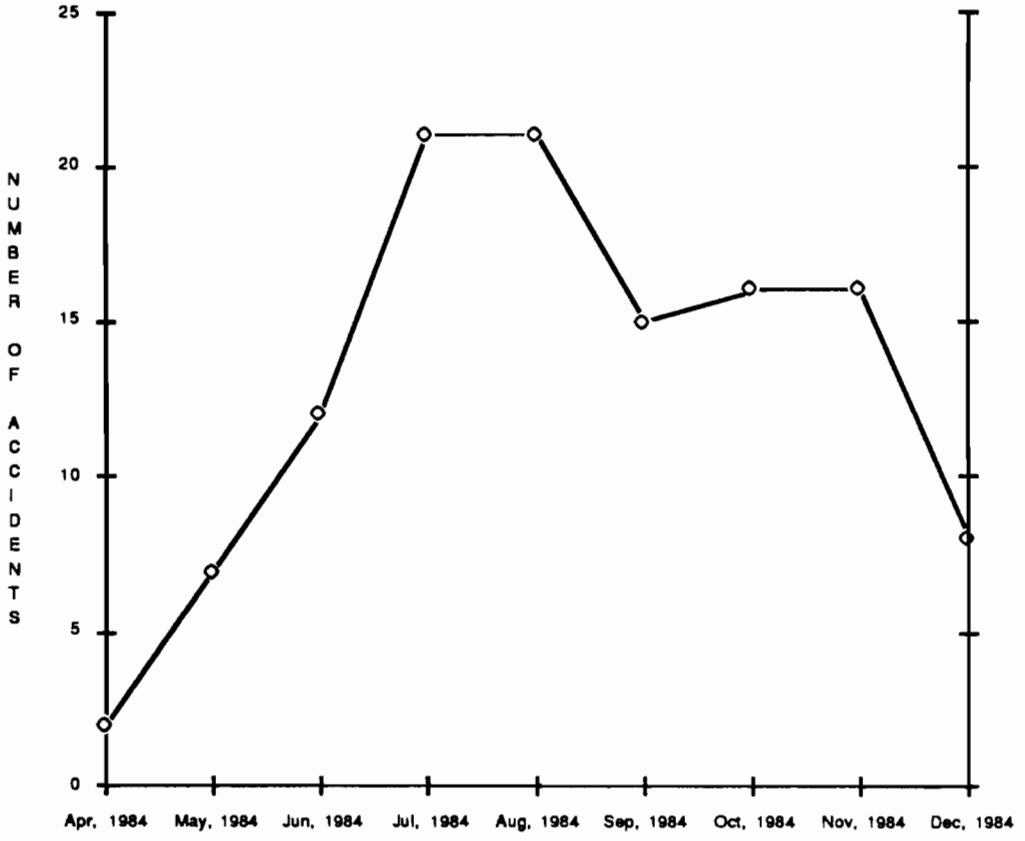


Fig 3.2. Number of accidents vs. month

TYPE OF MOWER

The most widely involved brand of mower was the Terrain King. Sixty-four Terrain King mowers were involved in accidents, as shown in Fig 3.3. There were 6 other miscellaneous mower accidents consisting of slope mowers, flail mowers, and edgers. Small riding or push mowers were also responsible for 15 accidents, mostly involving parked cars. The second largest group consisted of 30 other flex-wing mowers of various brands. These results should not imply that the Terrain King is the most dangerous. Tables 3.1 and 3.2 show that about 25 percent of the mowers used by the SDHPT are Terrain King, but only 14 percent of them were involved in accidents. Due to the large number of Terrain Kings, any modifications should be designed for this model.

VEHICLE REGION STRUCK

Figure 3.4 shows that windshields were hit over 39 percent of the time. The second most vulnerable place was the right side of the vehicle with 33 hits. The left side was also hit 19 times. Even the roof and underside were not immune to damage with 10 hits. Five rear windows were also struck while parked in parking lots. Most people only received a shower of glass when their windows shattered, but there were a few incidents of personal injury. Most of the damage was caused by rocks, but other debris, such as concrete, metal, wood, and an armadillo, was also thrown.

DIRECTIONS OF TRAVEL

Five directions were used to classify the positional relationships between the mowers and the cars (see Fig 3.5). The largest number of accidents (39) occurred with both vehicles traveling in the same direction and with the car to the left of the mower. The second largest group also consisted of vehicles traveling in the same direction, but to the right of the mower. Twelve vehicles were struck while traveling in the opposite direction, and to the left of the mower. Almost the same number were hit while traveling in the opposite direction and to the right of the mower. Six accidents occurred while the mower and car were perpendicular to each other. The remaining records did not list vehicle position.

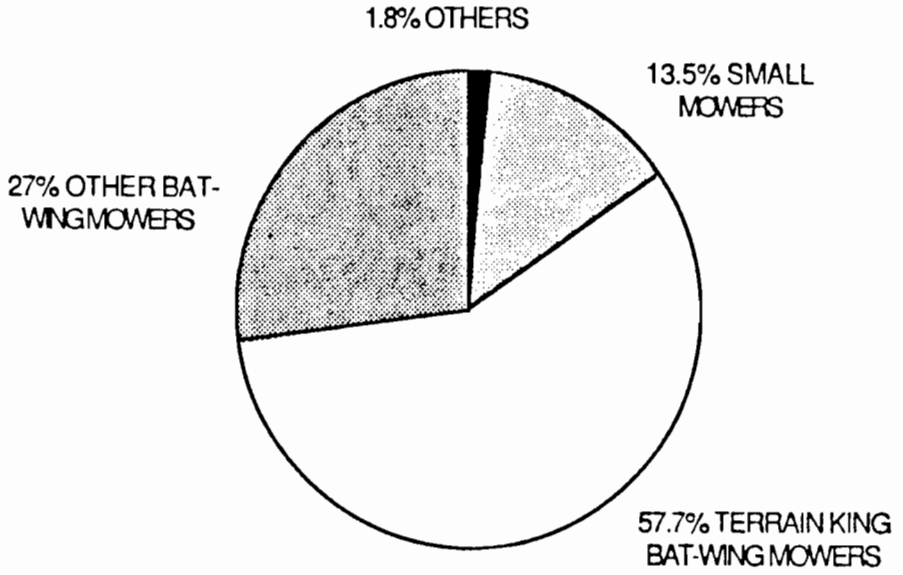


Fig 3.3. Mowers involved in M.T.O. accidents

TABLE 3.1. LIST OF MOWERS USED BY SDHPT

CLASS CODE	MAKE CODE		NUMBER OF UNITS
130010	95	(Brillion)	1
130010	202	(Danco)	1
130010	310	(Ford)	8
130010	609	(Mohawk)	10
130010	611	(Modern, Inc.)	22
130010	612	(Mott)	27
130010	662	(Perfect)	2
130010	758	(Safety Shear)	1
130010	769	(Servis)	3
130020	127	(Caldwell)	1
130020	172	(CMC)	1
130020	310	(Ford)	2
130020	570	(Mathews, Corp.)	6
130020	612	(Mott)	28
130020	662	(Perfect)	1
130030	201	(Dandl)	2
132010	118	(Bush-Whacker)	1
132010	127	(Caldwell)	3
132010	265	(Engler)	11
132010	299	(F & F)	5
132010	310	(Ford)	2
132010	429	(IHC)	13
132010	609	(Mohawk)	1
132010	611	(Modern, Inc.)	37
132010	769	(Servis)	7
132010	790	(SMC-Mowal)	6
132010	843	(Terrain-King)	22
132010	855	(Toro)	1
132010	966	(Woods)	5
132020	310	(Ford)	3
132020	609	(Mohawk)	1
132020	611	(Modern, Inc.)	27
132020	769	(Servis)	2
132020	843	(Terrain-King)	8
132020	966	(Woods)	22
132030	368	(Gravely)	1
132030	429	(IHC)	1
132030	611	(Modern, Inc.)	3
132030	987	(Yazoo)	1

continued .....

TABLE 3.1 - - continued

132040	36	(Astron Corp.)	1
132040	127	(Caldwell)	51
132040	265	(Engler)	2
132040	610	(Mowall)	8
132040	719	(Rhino)	6
132040	769	(Servis)	12
132040	834	(TCM)	11
132040	843	(Terrain-King)	469
132040	966	(Woods)	30
134020	611	(Modern, Inc.)	3

TABLE 3.2. CLASSIFICATION OF MOWERS
(FROM TACS SYSTEM - TABLE TEOS001 PAGE 9 9/30/85)

ARGUMENT VALUES	RESULTS VALUES
(130010)	(MOWER, LIFT OR TRAIL TYPE,) (FLAIL, 5 TO 7 FT.)
(130020)	(MOWER, LIFT OR TRAIL TYPE,) (FLAIL, 7 TO 9 FT.)
(130030)	(MOWER, LIFT OR TRAIL TYPE, COMB) (FLAIL, 14 FT. (FOR TRACTOR MTG.))
(132010)	(MOWER, LIFT OR TRAIL TYPE,) (ROTARY, 5 TO 7 FT.)
(132020)	(MOWER, LIFT OR TRAIL TYPE,) (ROTARY, 7 TO 9 FT.)
(132030)	(MOWER, LIFT OR TRAIL TYPE,) (ROTARY SWING ARM)
(132040)	(MOWER, TRAIL TYPE, ROTARY, 9) (FT. AND GREATER)
(134010)	(MOWER, LIFT OR TRAIL TYPE,) (REEL, 5 TO 7 FT.)
(134020)	(MOWER, LIFT OR TRAIL TYPE,) (REEL, 7 TO 9 FT.)
(135010)	(MOWER, SELF PROP., RIDING,) (FORWARD MOUNT, ROTARY, UP T0 60")
(135020)	(MOWER, SELF PROP., RIDING,) (FORWARD MOUNT, ROTARY, 60" CUT)

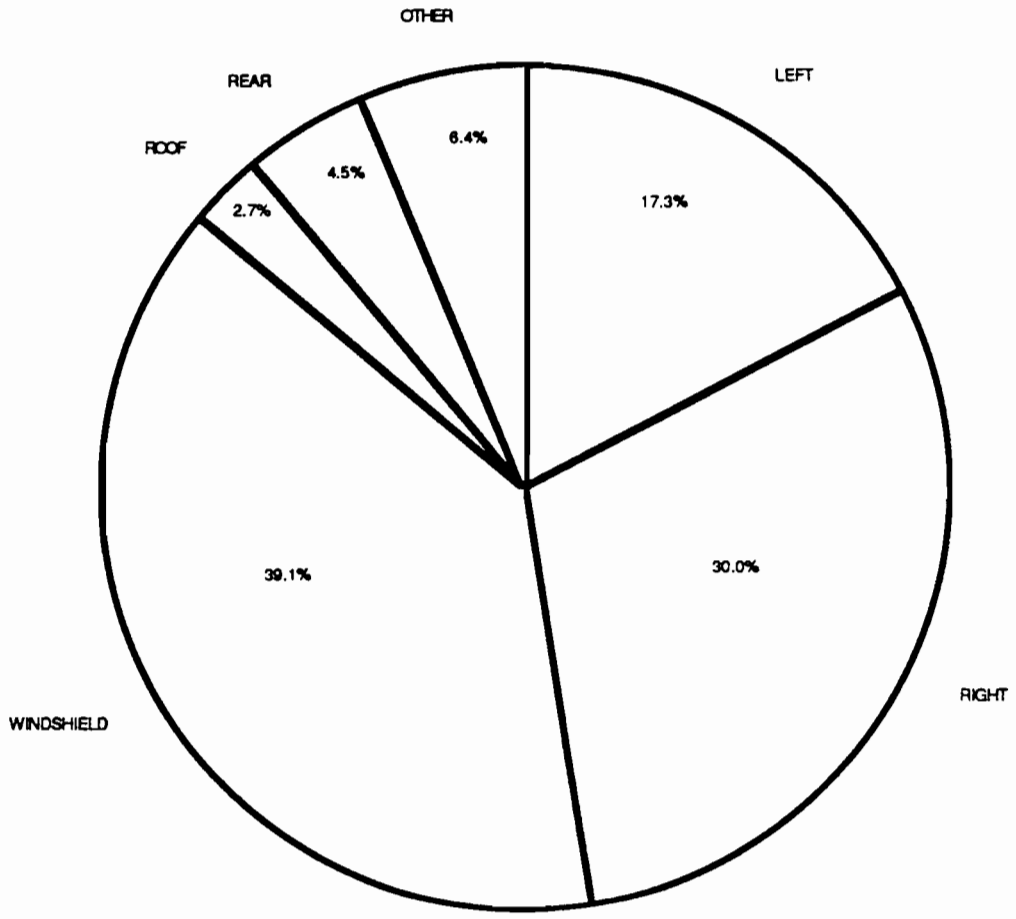


Fig 3.4. Regions of impact

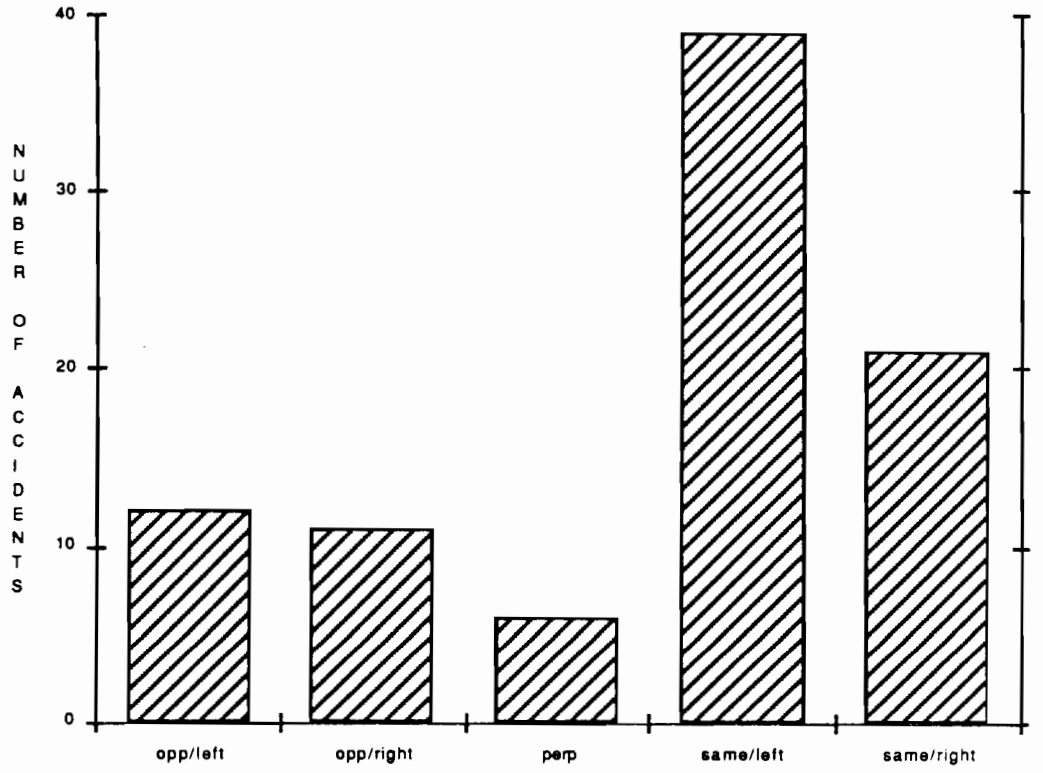


Fig 3.5. Number of accidents vs. mowing direction

CHAPTER 4. IDEAS FOR DESIGN MODIFICATION

This chapter explores possible alternative designs to solve the problem of mower-thrown-object accidents. The initial ideas generated for design modifications can be found in Ref 24. The alternative designs are divided into three parts. Part I contains proposed additions to the current mowing standards (see Appendix C). Part II describes equipment and modifications to equipment that are currently available. Finally, Part III considers original ideas as well as original modifications to existing equipment. The goal of all alternate designs is to reduce M.T.O. accidents at a reasonable cost.

PART I. STANDARDS

Restrict Minimum Height of Cut Grass to 6 Inches

Present mowing standards suggest grass cutting heights between 3 and 7 inches, depending on the grass. When the cutting height is low (3 or 4 inches), the probability of producing M.T.O.'s increases greatly since the mower blade is closer to the ground and closer to rocks on the ground. If the mowing height is made standard at 6 inches, it would be beneficial in several ways. First, it would save time since the mower cutting height would never have to be adjusted. A 6 inch cutting height would also raise the mower high enough to miss most rocks and debris that litter the ground. In addition, cutting grass too low in hot climates like Texas is bad for the condition of the grass and requires more watering. However, setting the cutting height at 6 inches may require the grass to be cut more often. A six inch cutting height is currently standard in many states.

Cut Grass only in the Early Morning

Statistically, most M.T.O. accidents occur in the mid-afternoon when traffic is heaviest (see Chapter 3). Thus, if mowing is restricted to the early morning there should be fewer accidents because there would be fewer motorists on the road to hit. The obvious disadvantage to this suggestion is the time constraint it imposes on the mowers. Mowers would have less hours per day to mow, thus it would take more days to finish a job.

Operate Mowers in the Direction Opposite to that of Traffic

Statistically, most accidents occur when the mower is traveling with the flow of traffic (see Chapter 3). This is because objects thrown from the mower travel in a path toward oncoming traffic. Thus, if mowers were required to cut in a direction opposite to that of traffic flow, many accidents could be avoided. When objects are thrown out in this direction, they will be traveling with the flow of traffic, thereby decreasing their impact velocity.

Use Herbicides to Control Grass in Rocky Areas

Rocky areas are defined as areas around guard rails and sign posts in addition to terrain that is rocky. In these areas it is better to control the grass with a herbicide than to cut it since there is a high possibility of rocks being thrown if mowers are used. However, herbicides are more time consuming to apply and do not always kill the desired vegetation. Herbicides will also harm the environment if not used properly (i.e., run-off).

PART II. AVAILABLE EQUIPMENT AND MODIFICATIONS

Mower manufacturers have equipment and modifications to equipment available that could help reduce M.T.O. accidents. This equipment may come as a standard feature on their mowers, or they can be retrofitted onto existing mowers. Some of these features are already present in the SDHPT mower purchase specifications (see Appendix D). The equipment effecting M.T.O. is classified under blade designs and guarding equipment.

Blade Designs

(A) Straight Blade

Currently the majority of bat-wing mowers are equipped with straight blades. The blade is made of 5160 heat treated steel (see Fig 4.1). The advantages of the straight blade are:

1. The blades are reversible for added service life.
2. The blades are inexpensive to replace.

Unfortunately, due to the heavy weight of the blade, larger objects are more likely to be thrown from under the mower. These thrown objects could cause serious damage.

(B) Lift Blade

This blade design is an alternative to the straight blade used on the bat-wing mower. Since the cutting edge of the blade is pitched (see Fig 4.1), it will create lift and produce a greater cutting efficiency. However, this blade will provide a greater surface area for contact with large objects thus creating potential for mower thrown objects.

(C) Double Pivoted Flat Blade

This blade has two pivoted points: one at the drive shaft hub and the other at the cutting edge (see Fig. 4.1). When the blade rotates, centrifugal force will hold the blades in position. The advantages of the double pivoted blades are:

1. The addition of the pivoted cutting edge permits the blade to retract back upon striking an object which it cannot cut.
2. The blade is available either as a pitched blade or straight blade.
3. The impact and cutting force of the blades are increased.
4. The horsepower requirements are reduced.
5. The cutting blade is inexpensive to replace.

This type of blade was introduced by Terrain King in the 1950's but due to complaints of increased maintenance over the conventional blade, the blade was withdrawn from production and became an optional item. In addition, the double pivoted blade assembly is more expensive than conventional blades.

(D) Dishpan Blade

This blade is expected to be safer to operate with respect to M.T.O.'s since the center section is a disk which does not have any effective rock hitting surface (see Fig 4.2). The dish blade also possesses a greater rotational energy, due to its greater mass, than the bar blade, which increases its cutting efficiency over the bar blade. However, dishpan blades do cost more than bar blades.

(E) Trailing Edge Blades

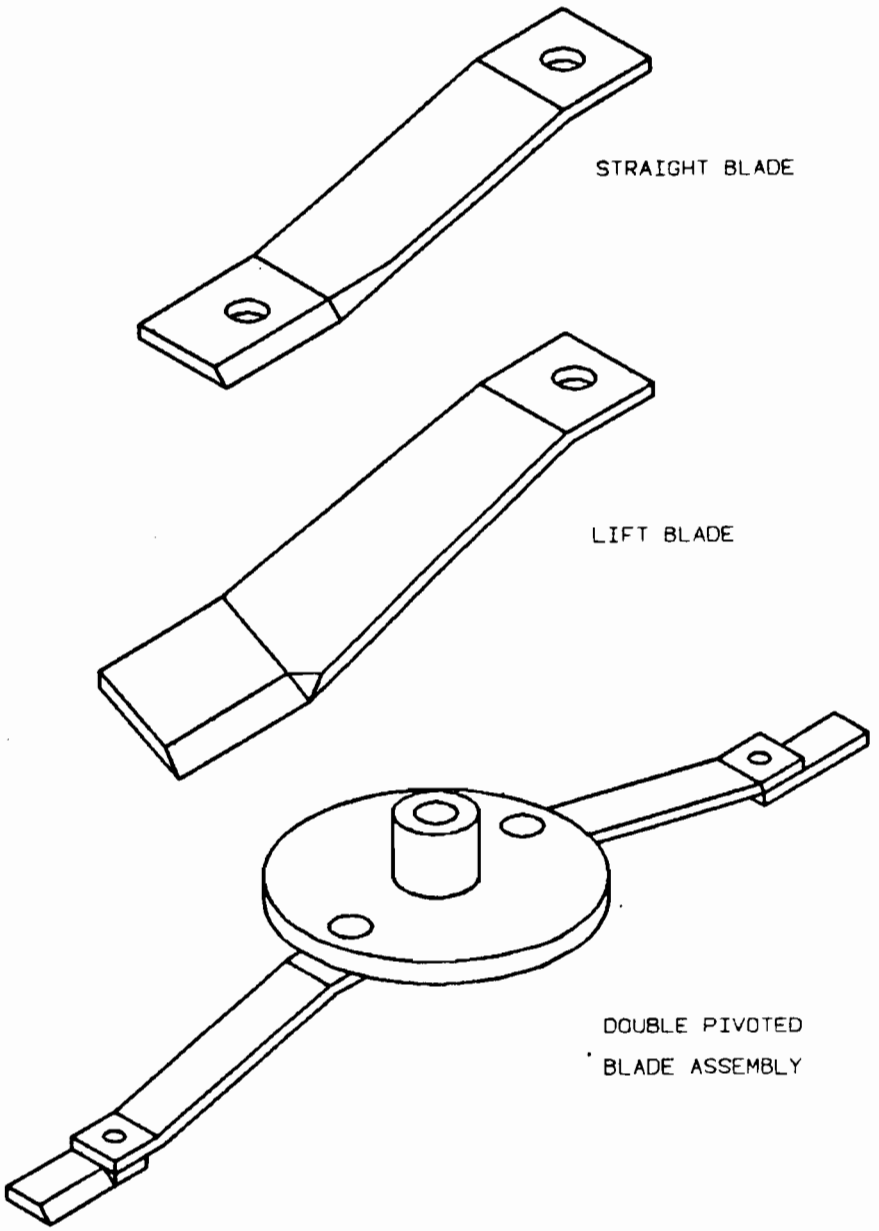


Fig 4.1. Blades currently available for bat-wing mower

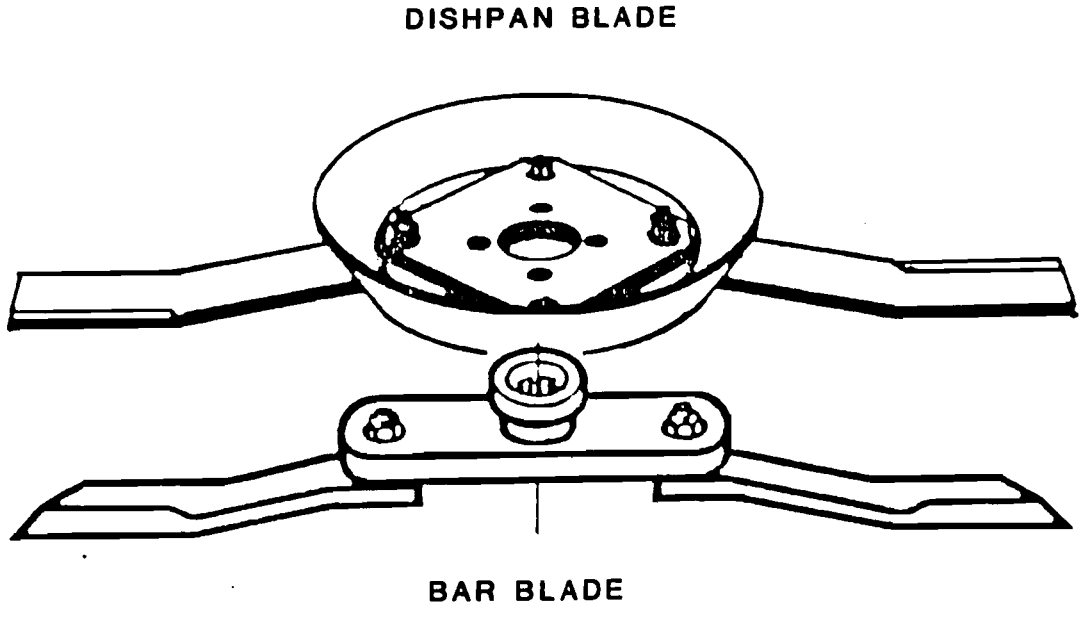


Fig 4.2. Dishpan and bar blade carriers (from Rhino cat. #: L-FWC-0884-5W-SWCG)

The trailing edge blade is a blade that has a slanted cutting edge. The blade is designed so that objects hitting the blade would be more likely to glance off the blade instead of being shot straight ahead after impact. The blade also incorporates a change in its center of gravity so that the reaction force the blade would have to overcome upon impact would be less. This would cause the blade to retract sooner than a conventional double pivoted blade. The blade is made of 5160 heat treated steel (see Fig 4.3).

Using the blade with a dishpan would optimize the effectiveness of the blade to reduce mower thrown objects (see Fig 4.4). If the blade strikes an object, the blade would retract and create a flush surface with the dishpan. This would prevent objects from being thrown by a bat-wing mower. However, the disadvantages would be:

1. Higher cutting speeds may be required to maintain cutting efficiency.
2. The cost of manufacturing this blade assembly could also be high if none were already available.

Note that the trailing edge blade can also be used on a double pivoted blade assembly.

Guarding Equipment

(A) Side Skirt

Side skirts are metal panels which attach to the sides of mowers to prevent material from flying out (see Fig 4.5). Skirts are only used on the sides because an opening is needed in the front and the rear of the mower for grass to enter and exit. Side skirts are designed to drag along the ground as the mower is being pulled. This creates a seal between the skirt and the ground that prevents M.T.O.'s from exiting. However, dragging the skirt increases the power requirements needed to pull the mower since extra drag is introduced. Maneuverability of the mower may also be hampered. Most mowers are equipped with replaceable side skirts as standard equipment.

(B) Automatic Self-Leveling Mower

This device helps the mower conform to the contour of the ground, thus reducing gaps and openings from which M.T.O.'s can fly out (see Fig 4.5). This feature is appearing on many of the newer mowers being produced. The increase in costs for the addition of this feature can be high.

(C) Existing Mower Chains

Safety chains help prevent rocks from flying out (see Fig. 4.6). They are hung along the sides of mowers and in places where skirts can not be used. Chains are the most common solution to M.T.O. accidents. Safety chains usually provide adequate protection from M.T.O.'s, especially when hung in double rows. However, M.T.O.'s sometimes have enough velocity and momentum to actually kick up the chain and exit the mower. Chains also barely touch the ground, so going over bumps or uneven terrain would create holes in the wall of chains for M.T.O.'s to exit.

PART III. ORIGINAL IDEAS AND ORIGINAL MODIFICATIONS TO EXISTING IDEAS

The following are original ideas generated by the design teams to meet our design requirements for reducing M.T.O. accidents. The ideas are classified under blade modifications and alternative guarding equipment.

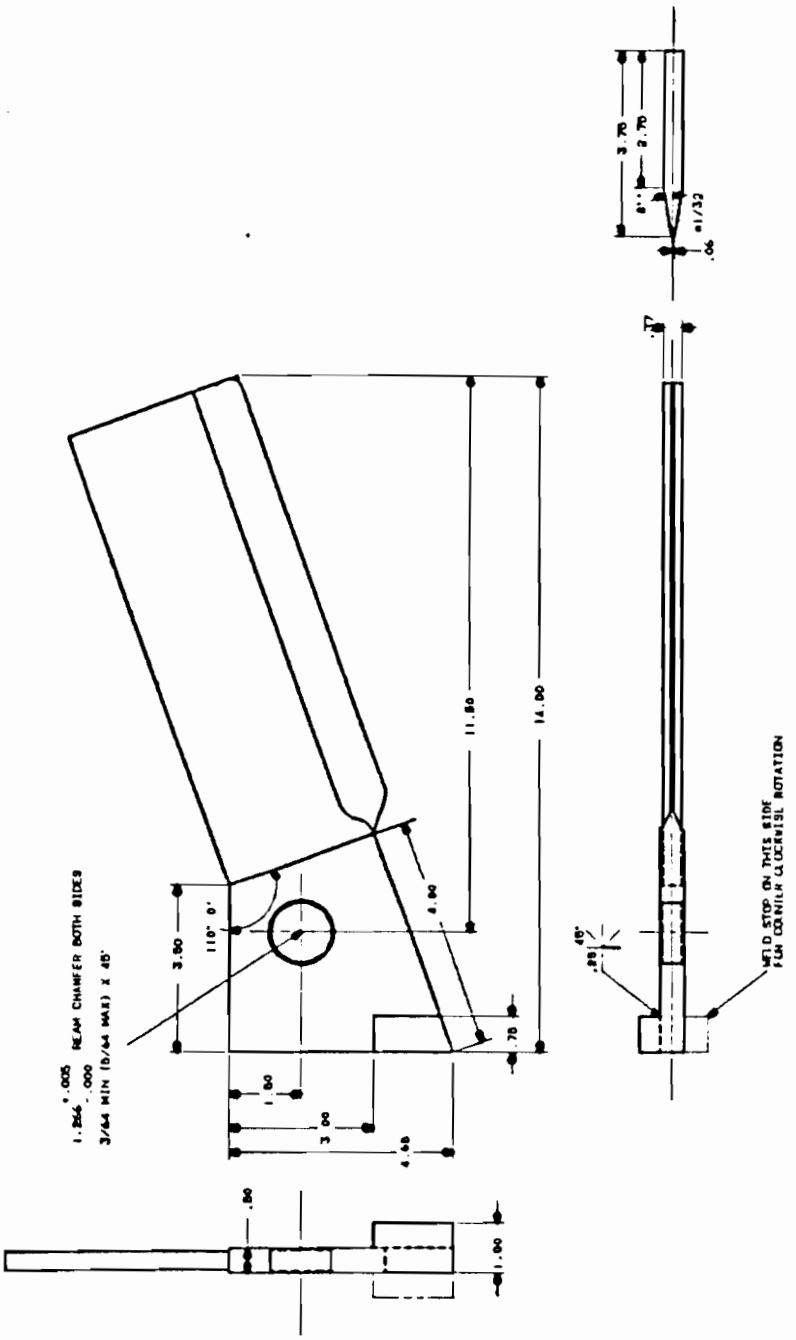


Fig 4.3. Trailing edge blade configuration

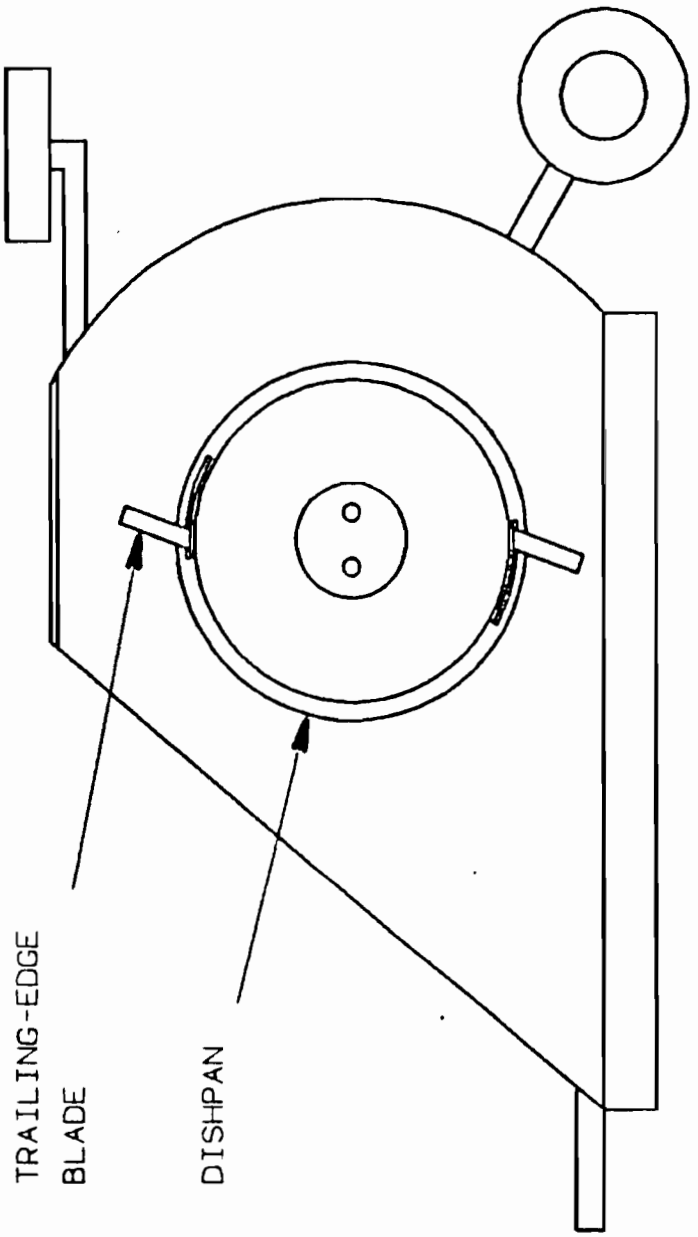


Fig 4.4. Dishpan with trailing edge blades

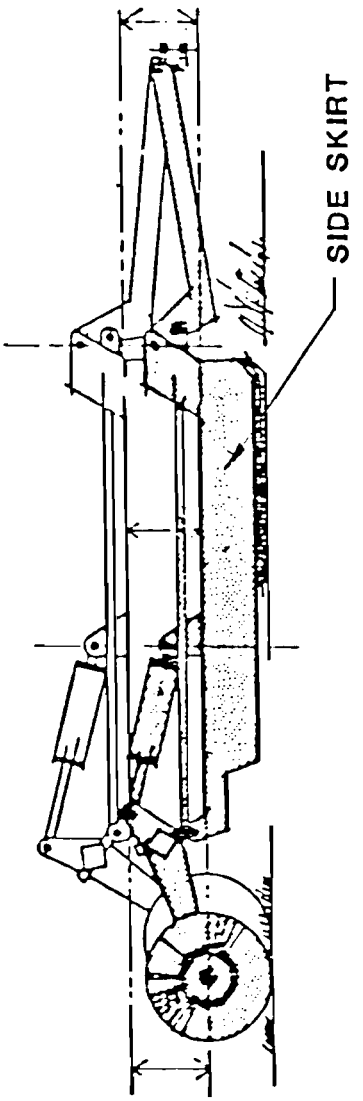


Fig 4.5. Automatic self-leveling mower w/side skirt (from Rhino cat. #:L-FWC-0884-5M-SWCG)

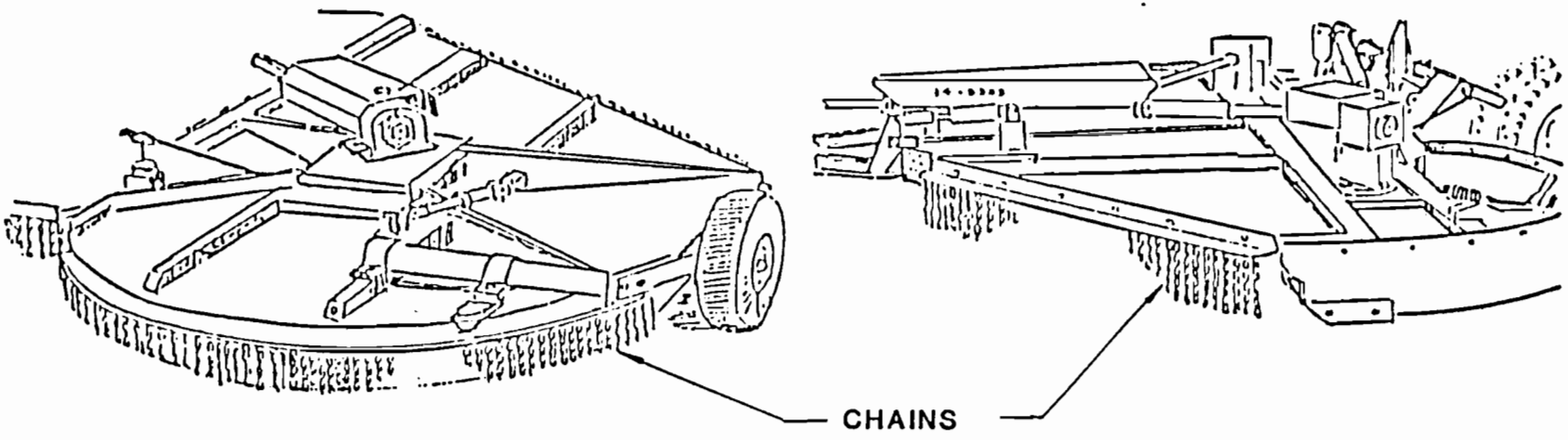


Fig 4.6. Existing mower chains

Alternative Blade Designs

(A) Reduced Mass Blade
A major problem with the blades previously discussed is their mass. A reduction of the mass of the blades would decrease the amount of energy transferred to objects thrown by the mower. Reduction of blade mass could be accomplished by:

1. Drilling holes to remove mass from the arm of the blade (see Fig 4.7).
2. Replacing the arm of the blade with different materials such as aluminum alloys and fibre-reinforced epoxy materials (see Fig 4.7).

However, the structural integrity of the blade may be destroyed if holes are drilled. Using different types of materials for the arm of the blade, may make the blade weak or not durable enough to withstand the impact caused by a blade striking an object.

(B) Blade Assembly with Three Blades
This blade configuration uses three smaller blade assemblies (see Fig 4.8). This blade configuration replaces the typical blade assembly used on the bat-wing mower.

By using more blades to mow, the mass of each blade can be reduced. This would then cause less energy to be imparted to an object when struck by the rotating blades thus preventing objects form being shot out from under the mower. Unfortunately, by using more blade assemblies, the assembly would require more mechanical linkages. This results in a greater cost to manufacture and maintain once in operation.

(C) Increased Lift Blade
Rocks hitting a lift blade would be deflected upward. The rocks would hit the mower casing instead of being shot out in a horizontal path. Increasing the blade pitch would also increase the lift created by the blade thereby standing the grass up to be cut. The increased lift would also blow the cut grass upward, so as to not clog the mower blades. However, increasing the pitch increases the rotating profile of the blade from a line to a rectangle. The new blade would have a greater surface area in which to hit objects which is undesireable. The cost of manufacturing these blades could also be high if none were already available.

(D) Wire Blade
A nylon wire blade would transmit much less energy when it hits a rock than a rigid steel blade (see Fig 4.9). Thus, a rock hit with a nylon blade will not have much energy to travel far or to cause M.T.O. accidents. However, this blade does not produce a lift. A regular mower blade has a slight pitch that creates a lifting force that stands the grass up, making mowing easier and more efficient. The nylon blade also does not have enough energy and inertia to cut very large plants. This could be remedied by using a more massive wire, for instance, one made of steel. However, broken pieces of the steel wire would be as dangerous as any M.T.O.

Alternative Guarding Equipment

This area explores the adaptation of floating skirts and deflectors. These devices could be designed and retrofitted to the existing bat-wing mower. Some of the following ideas were tested on a scale model; details can be found in Lu, Peng and Rao (Ref 2).

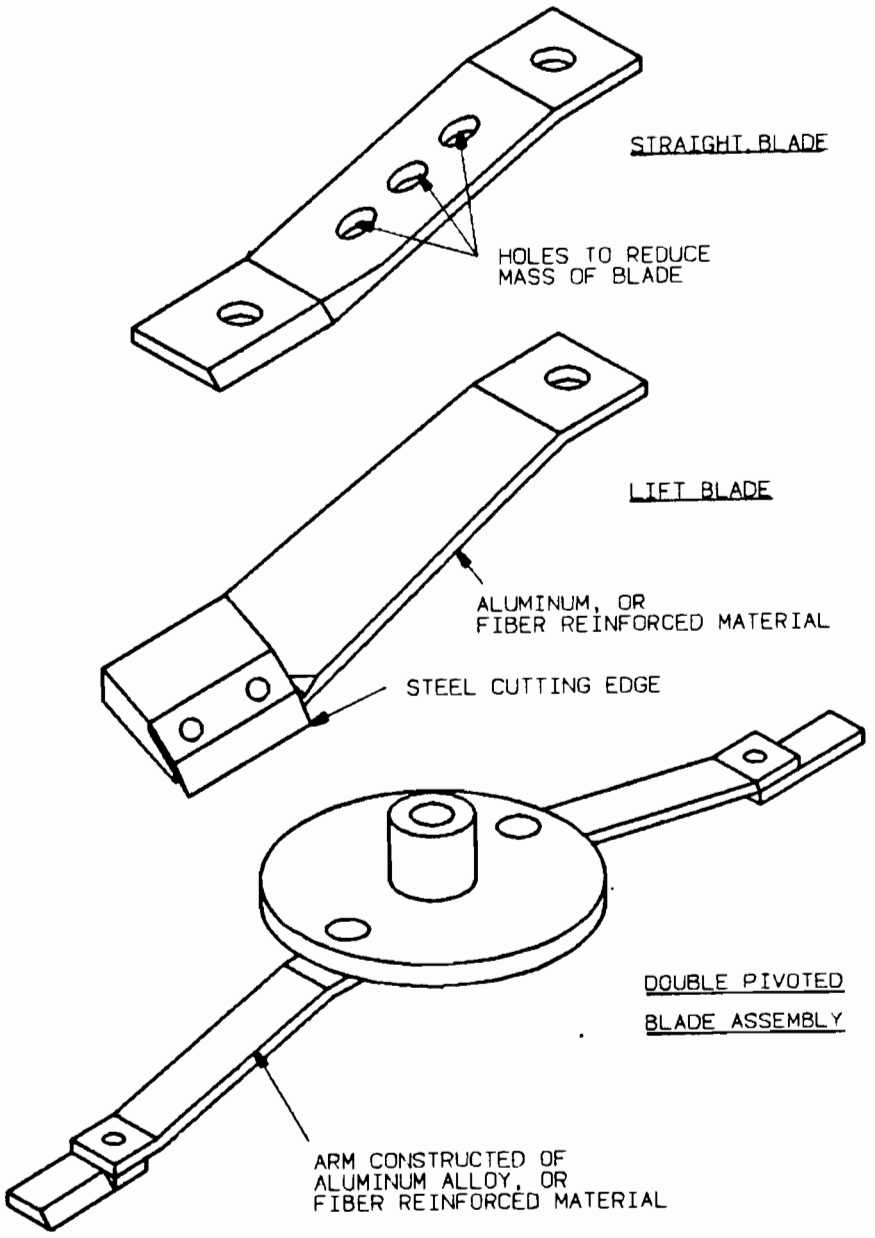


Fig 4.7. Alternate holes drilled and different materials used

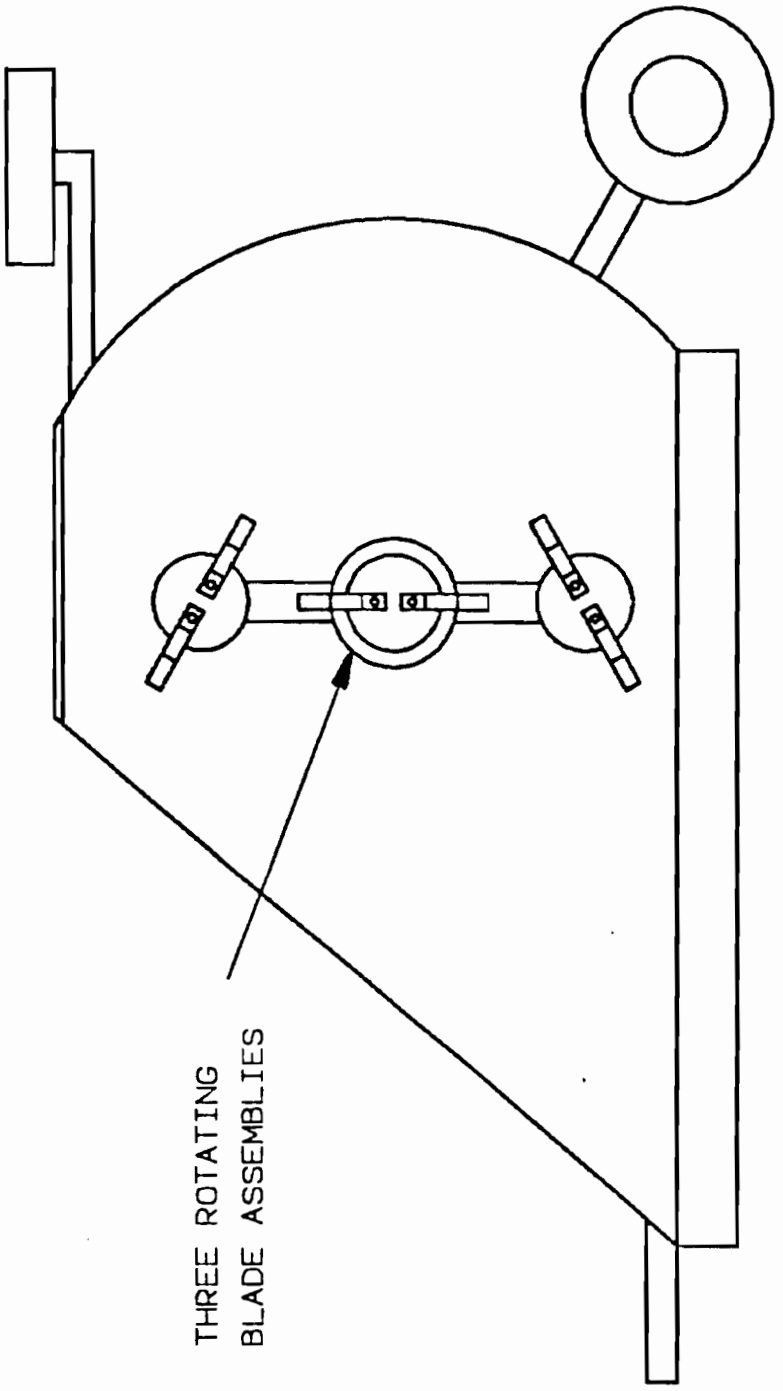


Fig 4.8. Three smaller blade assemblies mounted on the left-wing of the mower

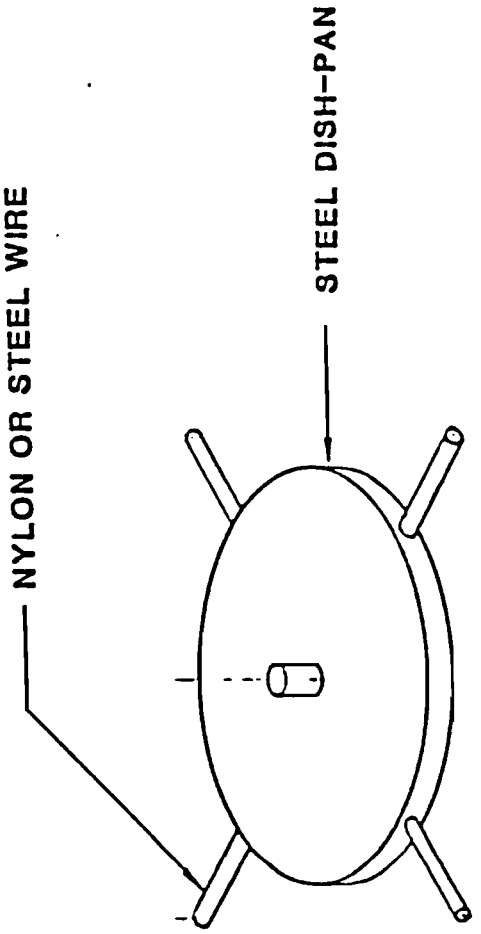


Fig 4.9. Wire blade

(A) Floating Side Skirts

The floating side skirts would be made of metal or rigid synthetic material which would be attached to the side of a mower. The skirt could only be used on the sides because an opening is needed in the front and rear of the mower for grass to enter and exit properly (see Fig 4.10). The advantages of the floating side skirts are:

1. This would allow the skirt to be bolted to the existing stationary side skirt.
2. Side skirts would have the ability to conform with the terrain during mowing.
3. Side skirts would prevent debris from being thrown out from under the mower.

However, the floating side skirts may have limited degrees of freedom thus possibly inhibiting the mower from turning sharply.

(B) Rear and Front Stand-Off Deflectors

Stand-off deflectors would be mounted on the front and rear of the bat-wing mower (see Fig 4.10). The advantages of the stand-off deflectors would be:

1. Materials could be made of double-linked chains, rubber flaps or fibre-reinforced material.
2. Cutting effiiciency would not be hindered.
3. Objects thrown out of the mower would be deflected downward.

The disadvantages would be:

1. They could be damaged by hitting stationary objects, due to irresponsible operators.
2. Possible matting of the grass could occur before cutting.

(C) Mower with Dragging Canvas

A fabric curtain is constructed out of canvas or tougher material (see Fig 4.11). The curtain is then bolted to a frame over the trailing edge of the mower. The frame can be raised and lowered for ease of mower movement. As the mower is operating, the curtain is lowered and allowed to drag along the ground. The main idea is for the curtain to be long enough so that rocks that hit it will stop and drop to the ground. The curtain is also dragged over grass cuttings so as to not inhibit the exhaust of grass and clog the mower blades. The problem with this idea is finding an optimal length of curtain to trail and finding a fabric tough enough to withstand dragging on the ground. This idea is only applicable in preventing objects from coming out the rear of the mower.

(D) Mower with Rubber Skirt

Hanging a skirt completely around the mower would prevent objects from flying out from any direction (see Fig 4.12). The solid rubber skirt is also more rigid than the flexible chains, so the chance of an object striking the skirt and exiting is lessened. The disadvantage of this idea is that while the skirt may prevent rocks from being thrown out of the mower, it may also prevent grass from properly exhausting. This would make the grass collect under the mower and clog the blades. The skirt may also, as the mower goes over the grass, have a tendency to mat the grass down instead of cutting it.

(E) Mower with Port

A port cut in the top of the mower casing would provide an exit for cut grass (see Fig 4.13). The

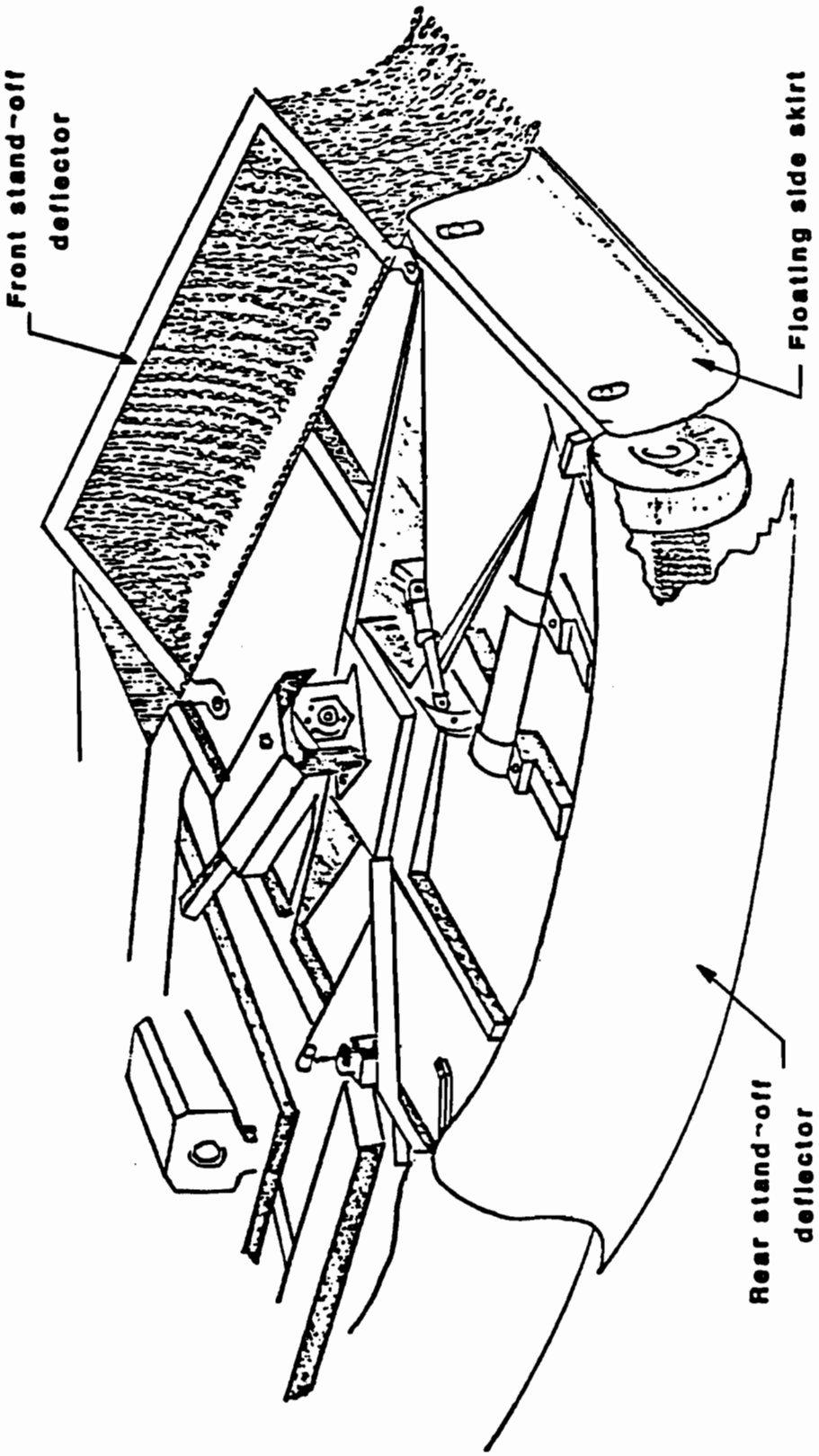


Fig 4.10. Protective external equipment installed on bat-wing mower

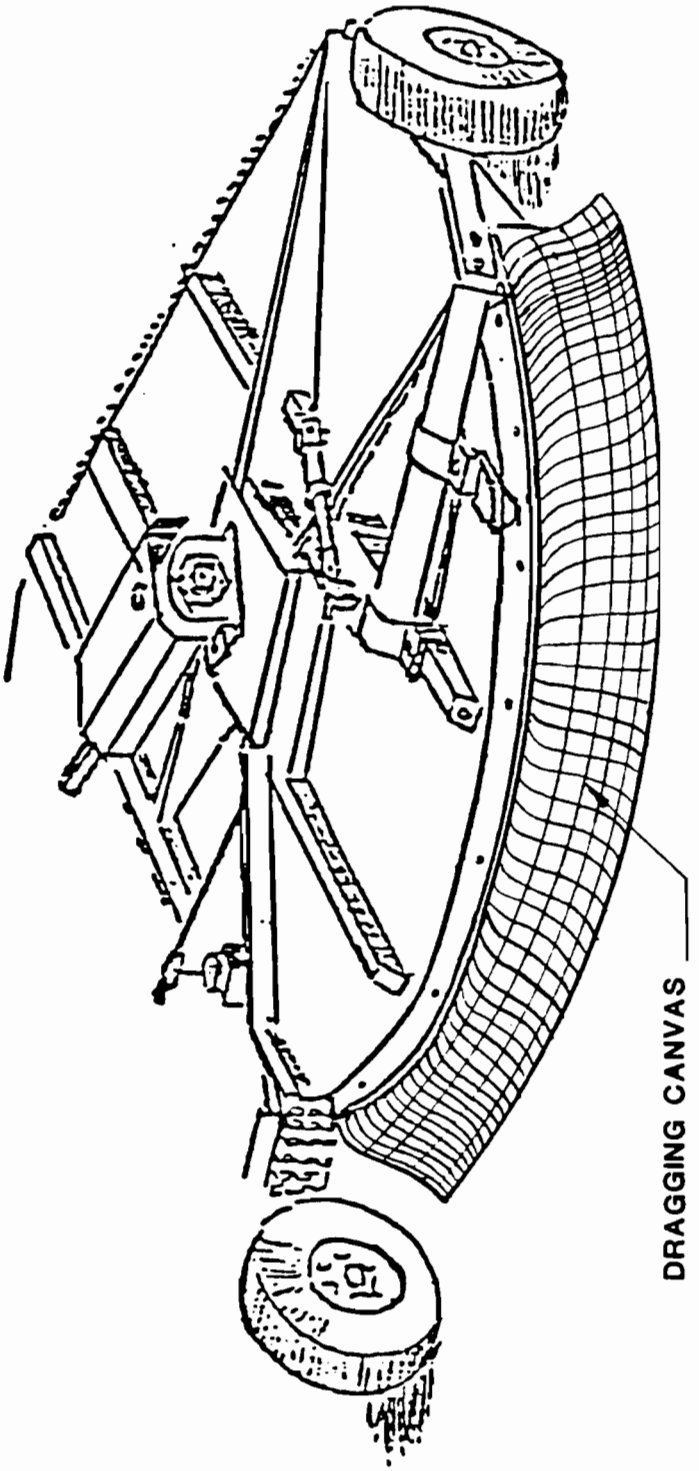


Fig 4.11. Mower with dragging canvas

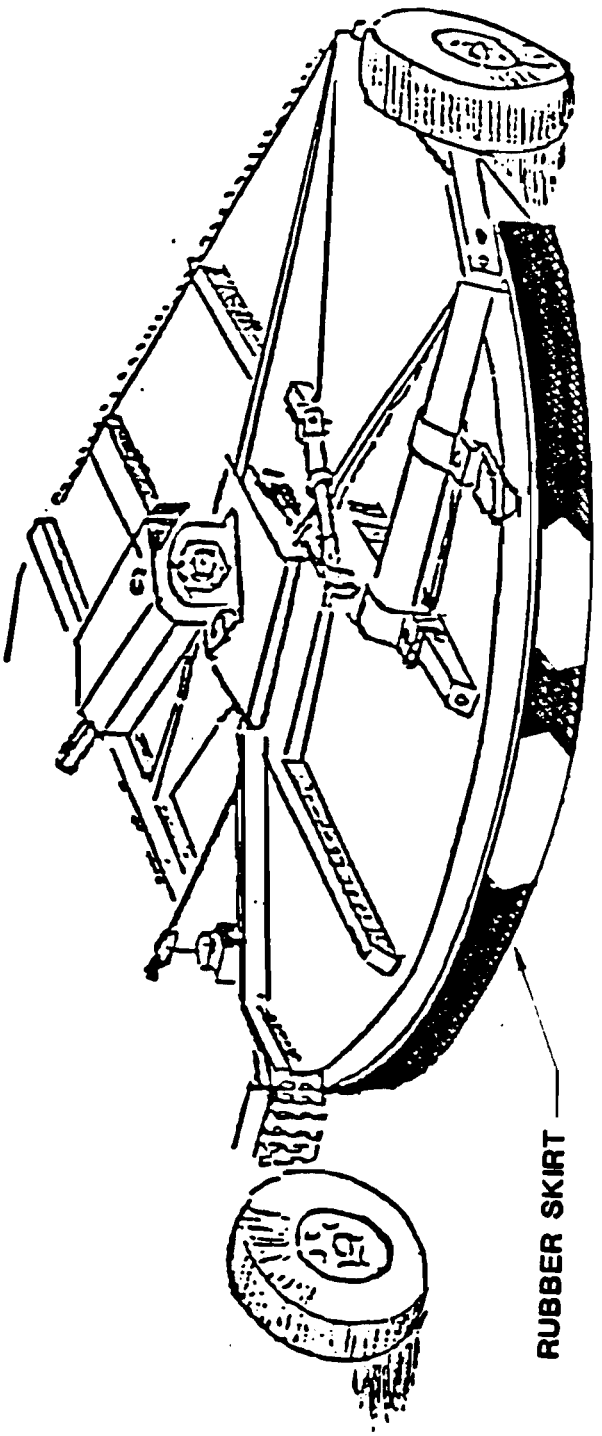


Fig 4.12. Mower with rubber skirt

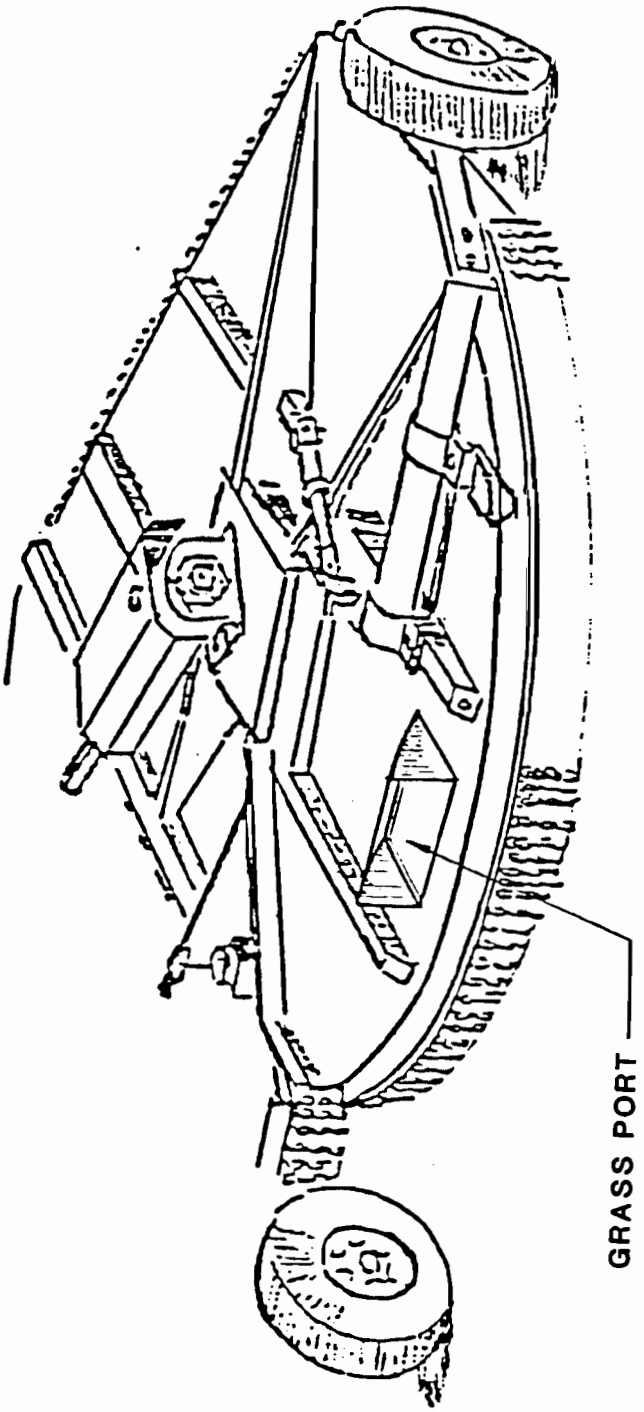


Fig 4.13. Mower with grass port

cut grass is light so it can be blown through the port by the lift created by the mower blades. The M.T.O.'s are heavy so they would just hit the sides of the casing instead of being blown out through the port. This idea would not work in places where the cut grass is heavy. The cost to modify the mowers may also be another limiting factor.

(F) Mower with Ducts

A duct system constructed under the mower casing would allow the operator more control over the exhaust of grass, making mowing more predictable (see Fig 4.14). The modification should be simple to make to existing mowers. Thin strips of steel railing are welded to the top of the mower casing. The exhaust grass could be aimed away from traffic as mowing is taking place. Modification costs should be low. Basic costs would be for the steel strips and the labor to weld it. Model testing and field testing would have to be done to find the required shape and position of the ducts.

(G) Mower with Baffles

M.T.O.'s may be hit repeatedly between the mower blade and the mower casing before it is finally shot out (see Fig 4.14). The M.T.O. builds up energy on being hit back and forth between the casing and the blade. A baffle system built into the casing could trap the rocks and keep them from bouncing around. This baffle could be easily constructed by welding a piece of steel to the inside of the mower casing . The entire casing of the mower could also be lined with a shock absorbing material to dissipate energy that rocks get when they do get hit. However, finding a material that is sturdy enough for this application may be difficult.

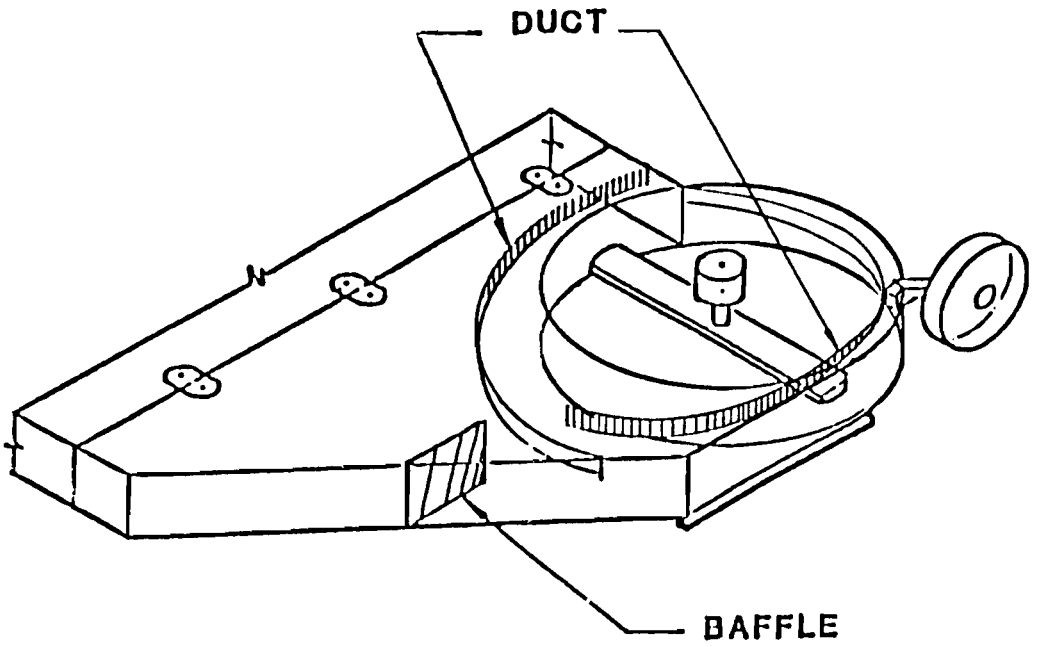


Fig 4.14. Mower with baffle and ducts

CHAPTER 5. DESIGN OF FIELD EXPERIMENTS

All experiments were performed at the Balcones Research Center firstly to determine what type of objects are hit by bat-winged mowers and secondly to find what happens to these objects once they are hit. A field was mowed so that an area of about 400 feet by 600 feet could be used. The Service Center at the Balcones Research Center was used for fuel, supplies, and for tools needed in changing the blades. The experiments were performed to determine the effects of the following variables:

- Object size
- Object mass
- Location of object's entry under mower
- Direction on mowing (forward, backward)
- Chain and cable guards (with, without)

While adjusting those variables, blade height, blade type, and blade speed were held constant. Data determined from the experiments are as follows:

- Distance traveled by mower-thrown-objects
- Direction traveled by object with respect to the mower.

This data enables the variables of size, mass, and entry point to be related to the distance and angle of the object's path. Also, the angle of travel allows the determination of the object's approximate exit point from the mower.

OBJECTS TESTED

Rocks are the most common type of objects hit by SDHPT mowers and are dangerous when thrown because of their weight. Therefore, rocks are important objects to be used for testing. Cans and bottles are also common objects encountered during mowing. However, it was found during preliminary testing that cans weighted with sand tended to get cut instead of being thrown. It is believed that bottles too get shattered instead of being thrown. Bottles were not used for tests because of the danger of splintered glass covering the test area. Other common objects considered were rubber pieces, wire and wood blocks. Rubber is not considered very dangerous as a thrown object while wire is quite the opposite. Wire tends to wrap itself around the blade and fly off at a later time unexpectedly. In addition wire wrapped around the blade near the shaft can cause damage to the gear box bearing seal. Wood pieces are commonly encountered during mowing and are hit by the blade and thrown long distances. Also wooden blocks are easily available and their size can also be easily controlled which makes them ideal test objects.

On the basis of the above considerations, wooden blocks and rocks were chosen as test objects. The wooden blocks used in extensive testing are pressure treated cedar measuring 3-1/2 inches x 3-1/2 inches x 4 inches. Two types of rocks were used in preliminary testing. The first type of rock was three to five inch limestone rip rap. These rocks gave positive results in preliminary tests and are very common in Texas. The second rock type was 1-1/2 to 4 inch bull gravel. This type of rock was found to be too small to be hit by the mower blade. Therefore, of the two types of rocks, only limestone rip rap was used in the extensive testing.

Supplies used in the experiment are as follows:

- 3-1/2" x 3-1/2" x 4" pressure treated wooden blocks with a weight of about 1 pound.
- 3" to 5" limestone rip-rap with a mean weight of about 5 pounds.
- 1-1/2" to 4" bull gravel (preliminary tests only).
- Aluminum beverage cans filled with sand (preliminary tests only).
- Red, blue, orange, green, gray, brown, black, and white spray paint to mark the objects for testing.

Preliminary testing indicated that two types of objects should be used; they are four inch cube pressure treated wooden blocks and three to five inch limestone rip-rap.

MOWER AND MOWER MODIFICATIONS

The tractor used in the experiment was a model 2656 International Harvester. Based on the M.T.O. accident reports of 1984, described in Chapter 3, it was found that eighty-five percent of the accidents involved bat-wing type mowers. Terrain King mowers were involved in two-thirds of these accidents. With this information a Terrain King mower furnished by Terrain King was used in the experiments. The mower used was a Terrain King, model TK15-IV, batwing mower with lift blades and a 15 foot cutting span (see Fig 5.1).

The working parts of a rotary mower consist primarily of a drive input shaft, a blade bar, and two blades. The connection between the blade and the blade bar is critical to the safety and performance of the mower (see Fig 5.2). This nut and bolt joint acts as a pivot about which the blade may swing. In this way the blade swings back when it strikes a large or immovable object. The nut and blade bolt are strong enough to sustain repeated shocks for the life of the blade, which is typically about eighty hours of use.

In actual use, the blade very rarely swings back. The steel blade currently used has so much momentum when rotating at the operating speed of about eight hundred revolutions per minute (or a blade tip speed of about one hundred sixty five miles per hour) that only very large objects cause it to swing back. Smaller objects may be thrown at speeds as high as the blade tip velocity. These are usually deflected by the steel housing or chain guards on the mower. Those objects that are not deflected are the source of mower thrown object accidents. The distance these objects are thrown can be reduced by lowering the blade momentum. However, a minimum level of momentum is necessary to maintain cutting efficiency.

To reduce the velocity of objects leaving the mower, small chain lengths are hung above openings in the front and back of the mower. Chains are used on all bat-wing mowers and considered to be the most effective means of reducing M.T.O.'s. In field operation these chains are sometimes missing or damaged. Therefore it is important to test the dangers involved in mowing without these safety guards. Recently, mower manufacturers have strung cables through lower links in the safety chains (see Fig 5.3). When an object strikes a chain the impact is distributed to surrounding chains. But, like the chains, the cables are sometimes removed or torn off and not replaced. Therefore, it is important to test the reduction in safety associated with the absence of these cables. To study the effectiveness of existing safety devices on bat-wing mowers, three test conditions were considered:

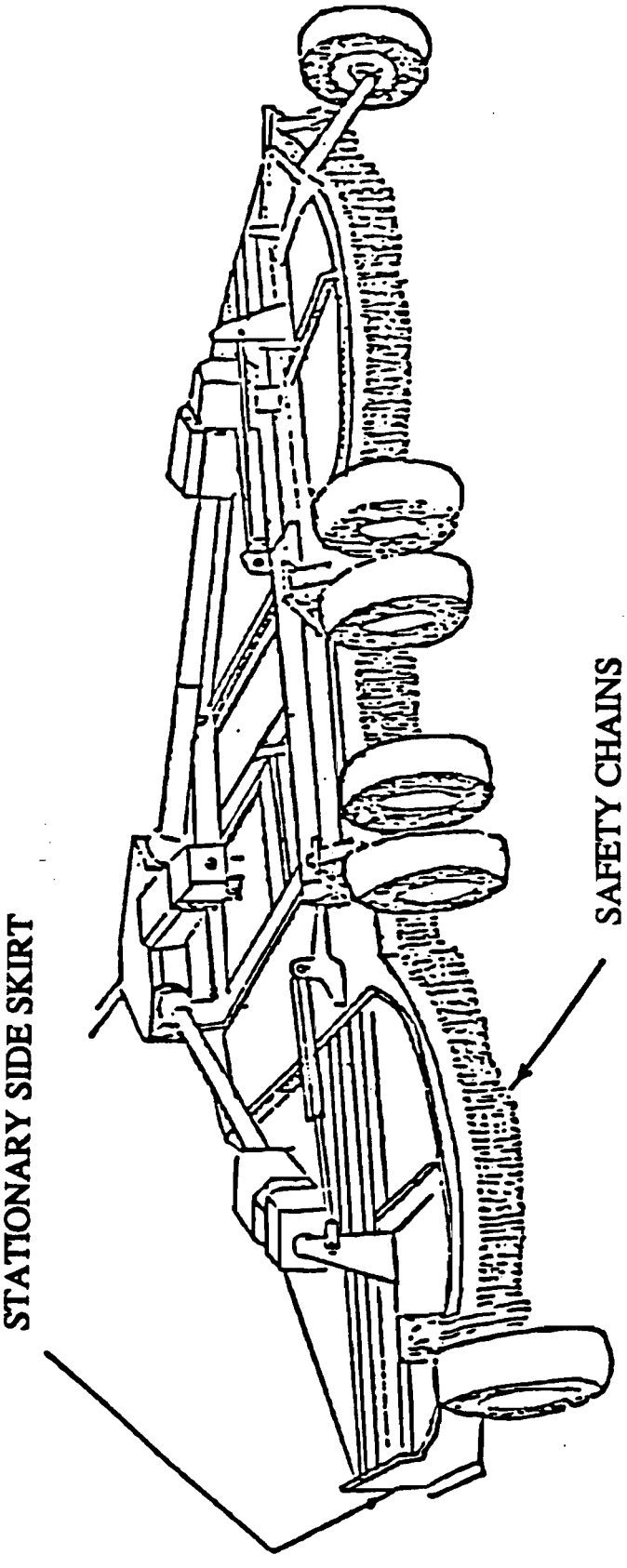
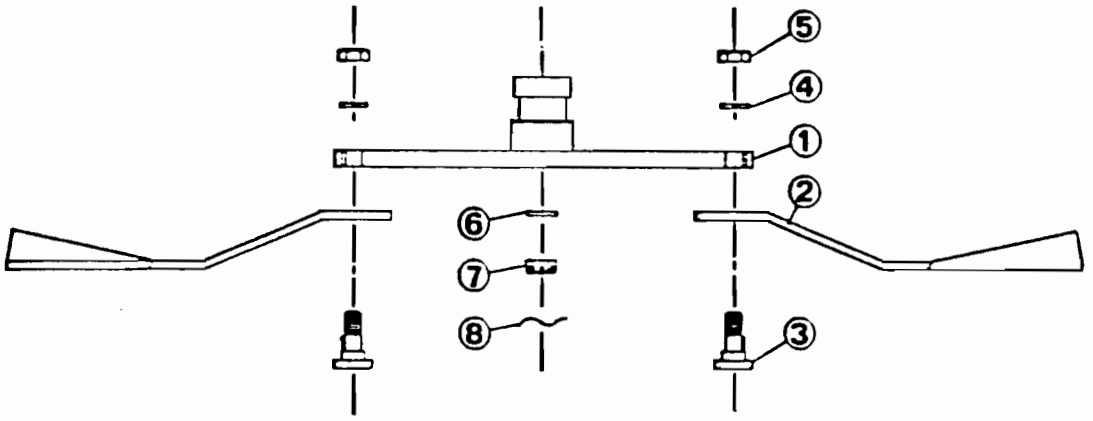


Fig 5.1. Bat-wing mower



TORQUE ITEM #7 to 250 FT. LBS.

TORQUE ITEM #3 to 250 FT. LBS.

ITEM	PART NO	DESCRIPTION	QTY
1	00752142	BLADE BAR	1
2	00750787	RIGHT WING UPDRAFT BLADE	2
	00750788	LEFT WING UPDRAFT BLADE	2
3	00735900	BLADE BOLT	2
4	00748000	LOCKWASHER	2
5	00747900	NUT	2
6	00606200	WASHER	1
7	00606100	CASTLE NUT	1
8	00751130	WIRE RETAINER	1
	ITEMS LISTED BELOW ARE OPTIONS AND ARE NOT ILLUSTRATED		
9	00752152	STUMP JUMPER ASSEMBLY - RIGHT WING	REF
10	00752153	STUMP JUMPER ASSEMBLY - LEFT WING	REF
	THESE ASSEMBLIES CONSIST OF STUMP JUMPER PAN WELDMENT, BLADES AND ALL ITS HARDWARE		

Fig 5.2. Blade bar assemblies

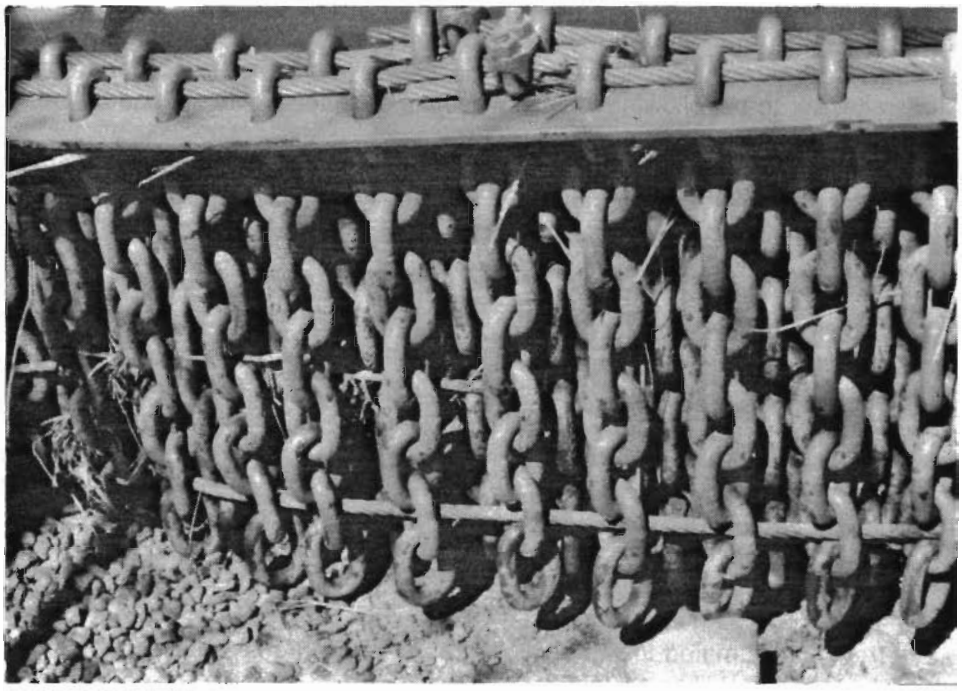


Fig 5.3. Safety cable through chains

(1) mowing with chains and cables
(2) mowing with chains and without cables
(3) mowing without chains and without cables.

EXPERIMENTAL PROCEDURE

After preliminary testing of different objects by different methods, a set of final procedures were developed to run the experiments. A level area of 400 feet by 600 feet was used for mowing in the forward and backward directions using wooden blocks and rocks placed at predetermined locations. The specific procedure to be following while conducting such tests is described below:

1. Fifteen equally spaced stations along the mowing width are measured for placing the objects. The stations are staggered along the path of the mower as shown in Fig 5.4. As the exact point of each station is determined, the point is marked on the ground with paint. Also a straight line for the tractor and mower path is painted.

2. Single objects are placed on the marked stations. Each object used in a run is painted a different identifying color. All stations are not used in each run. The odd numbered stations are used in the first run and the even numbered stations are used in the second run.

3. The tractor is used in first gear with a power-take-off speed of approximately 540 rpm. The cutting height of the mower is four inches. With these things set, each run consists of running over the staggered formation of even or odd numbered stationed objects once.

4. Objects that are hit by the mower are watched and found. By locating the object and referencing its original position, the distance of travel is measured to within an accuracy of five feet and the angle of travel is estimated to within 10 degrees. This data is recorded on charts as shown in Allen, Rinkevich, and Williams (Ref 25).

5. Many times an object would be hit and break into pieces, with the multiple pieces all being thrown. In these cases data was recorded for partial objects which were at least an eighth of the original size.

6. Each trial consists of two runs (one each for odd and even stations). A test consists of four trials in which the object used, mower safety equipment used and mowing direction are held constant.

The tests are repeated under various conditions: with and without chains and cables; forward and backward; and over level and uneven terrain. Uneven terrain could cause the blades of the mower to cut into the ground thus throwing debris. Also, as uneven terrain is mowed the safety chains and side shields may not touch the ground. As all of these conditons can affect safety, further development of experiments to test these conditions is desirable.

The detection of the M.T.O.'s was achieved by using the impact and locate method. The impact and locate method used to detect objects thrown from the mower assumed that the path of the object is best approximated by a straight line between the original position of the object and a point detected outside of the mower. The method involves pulling the mower over objects which are to be hit by the mower and locating the objects on the ground after they are thrown. This method requires a large open area and is dangerous in that there is no way to control or contain thrown objects. The

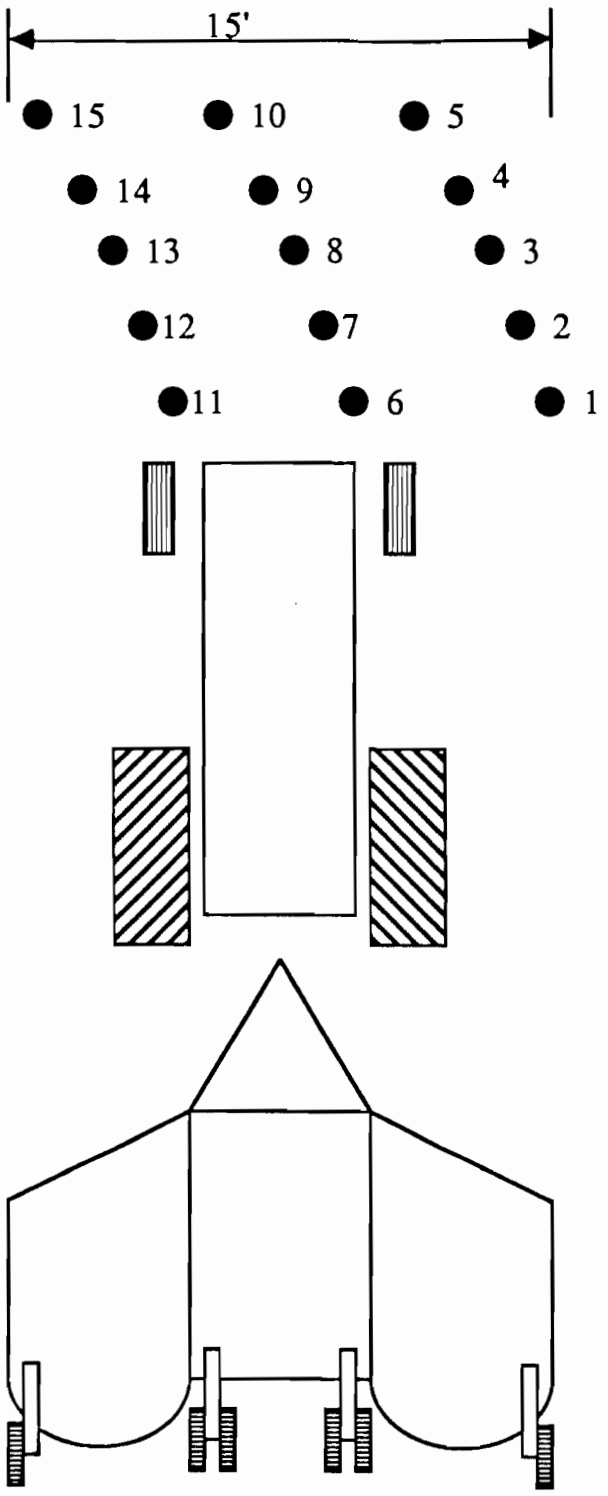


Fig 5.4. Staggered formation of objects for testing

advantage of this method is being able to determine how much energy is imparted to the object by measuring how far the object travels. By tracing the path between beginning and ending points, the relative exit position on the mower is also determined.

CHAPTER 6. RESULTS OF FIELD EXPERIMENTS

Using the experimental procedure described in the previous chapter, raw data was obtained for both rocks and wooden blocks in each of the four types of tests: forward with safety devices, backward with safety devices, forward without cables, and forward without chains; see Allen, Rinkevich, and Williams (Ref 25) for details. For each object hit and thrown the data gives two significant pieces of information viz, distance and direction. Distances are used to measure energy and thus compare the relative safety observed in each test. Direction of travel is used to locate the exit point and thus indentify problem areas of the mower. Additional information is obtained from observable evidence with regard to safety in mowing rough terrain and in raising or lowering of the mower's wings. The nature of the results obtained are discussed in the last section of this chapter. Details of the fabrication of reduced mass blades and results of field tests using them can be found in Bassignani, Lim, and Martinez (Ref 26).

PROCESSED DISTANCE DATA

Average distances are found over four trials and charted for each of the fifteen stations on each of the four tests. These averages are charted for rocks and for wooden blocks. Maximum distances are also found for each of the fifteen stations on each of the four tests. This is done similarly for rocks and for blocks.

For forward testing with blocks, distance of travel is plotted for each of the fifteen stations and for each of the four trials (see Fig 6.1). Trials are consistent except at stations 3 and 15. Although distance traveled usually can by predicted after several trials, this graph shows the possibility of an occurrance of an object traveling a long distance.

Comparison of Backward and Forward Mowing

(A) Average Distances for Blocks
Figure 6.2 allows backward and forward testing to be compared using blocks and their average distances. In 11 of the 15 stations, blocks travel a higher average distance in the backward testing. Also, the two highest averages are found in the backward testing (nearly 50 feet in stations 5 and 6).

(B) Maximum Distances for Blocks
The bar chart of Fig 6.3 compares forward to backward testing for blocks by taking into account their maximum distances. Testing forward produced the largest distance traveled (102 feet), but backward testing produced a longer maximum distance in 10 of the 15 stations. Also, backward testing has ten maximums over 25 feet compared to eight maximums over 25 feet for the forward testing. This is better seen by considering the average of the maximum at each station. For forward testing the average of these maximums is 37.5 feet and for backward testing it is 42.8 feet.

(C) Average Distances for Rocks
The bar chart of Fig 6.4 compares forward to backward testing with rocks using the average distance traveled at each station. Rocks consistently travel farther on the average in backward

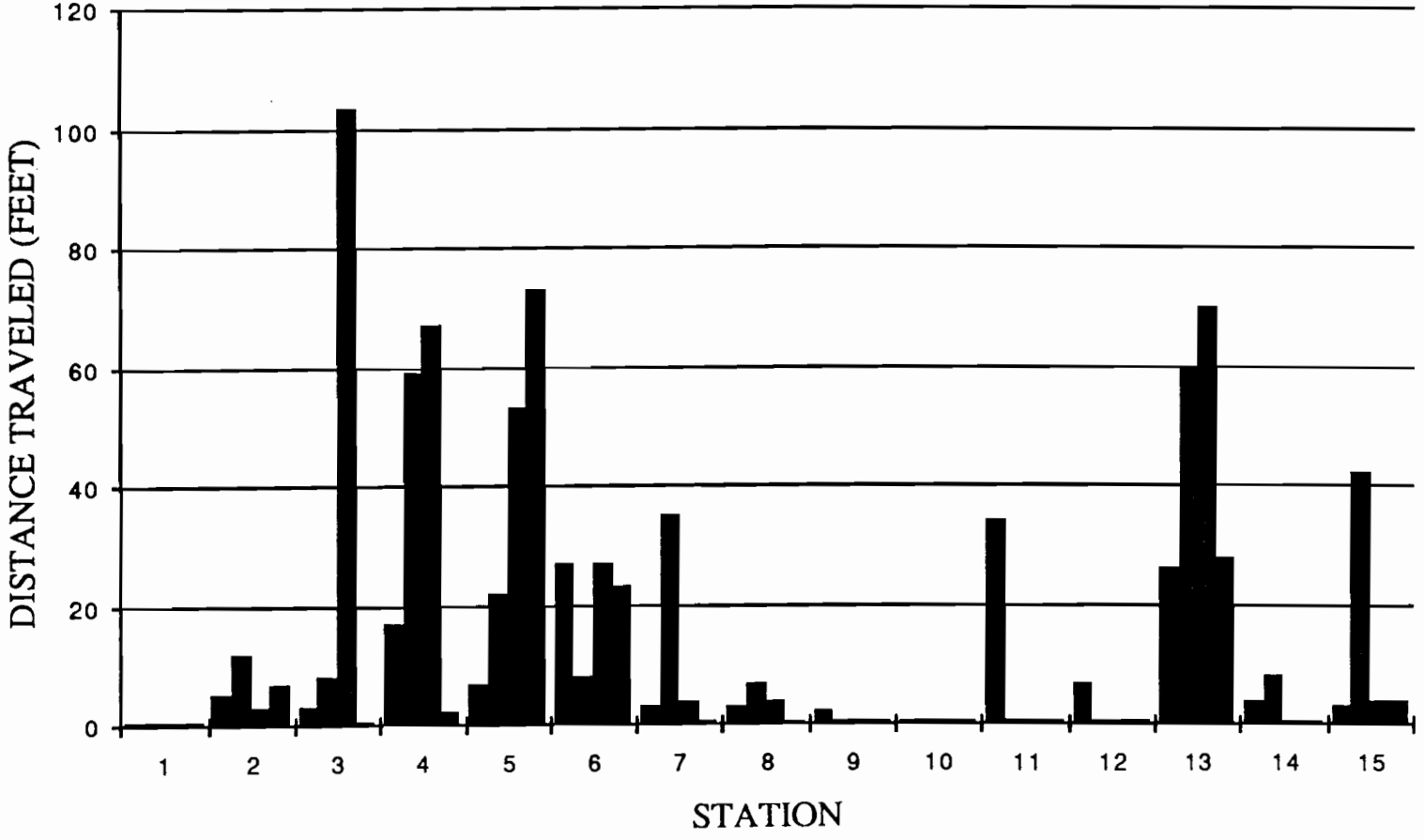


Fig 6.1. Distribution of data for blocks with all safety devices on mower (forward)

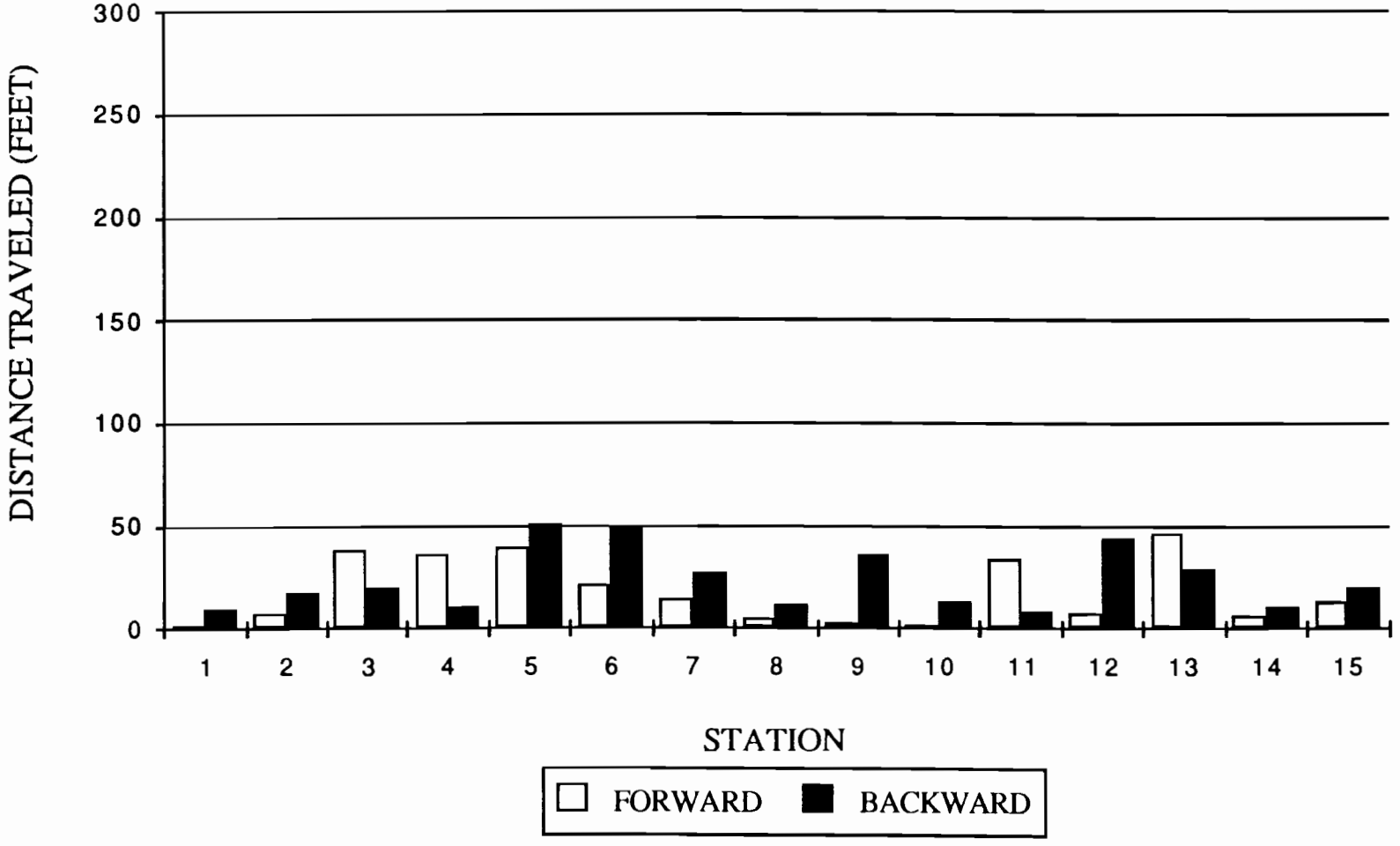


Fig 6.2. Comparison of average distances for blocks in forward and reverse directions

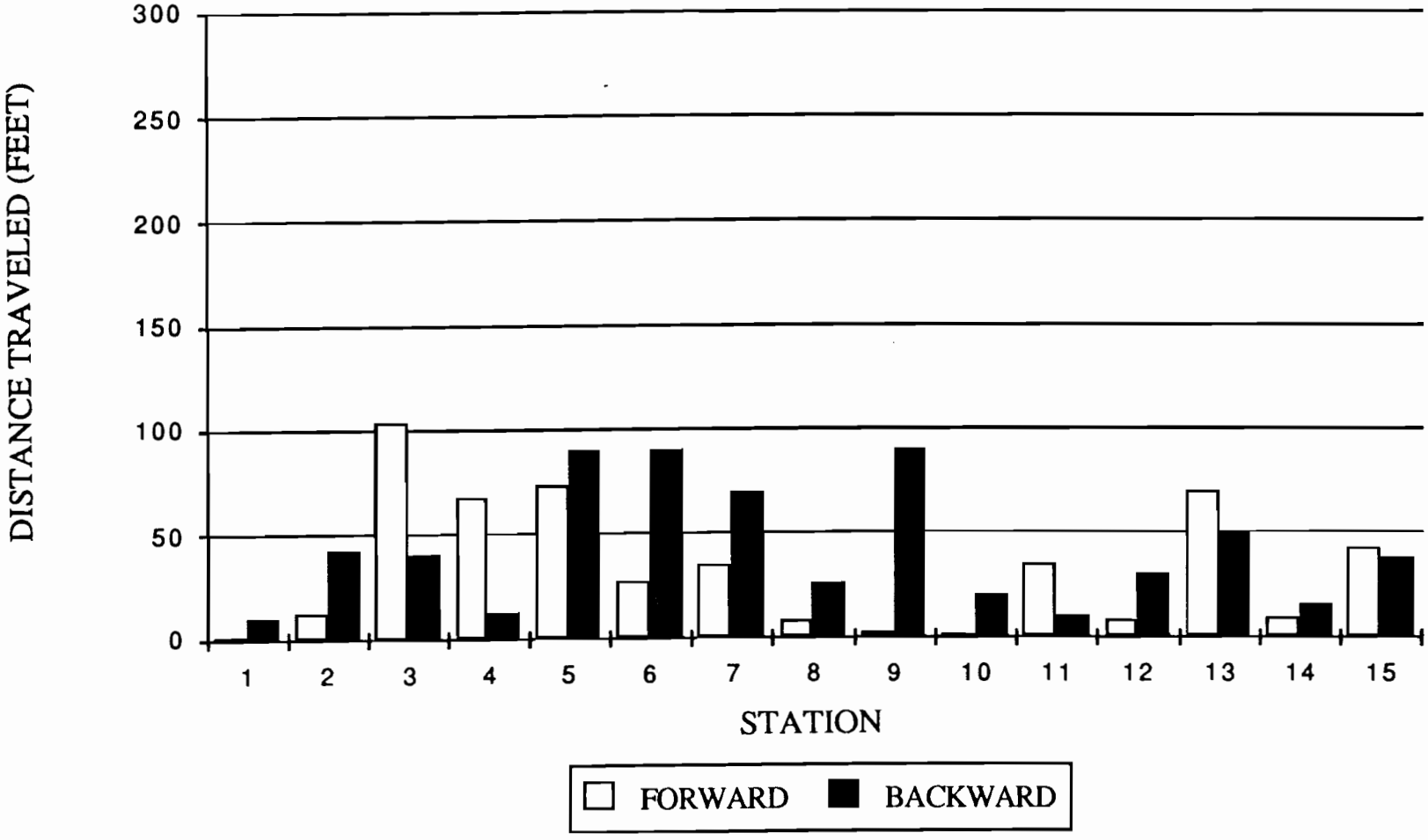


Fig 6.3. Comparison of maximum distances for blocks in forward and reverse directions

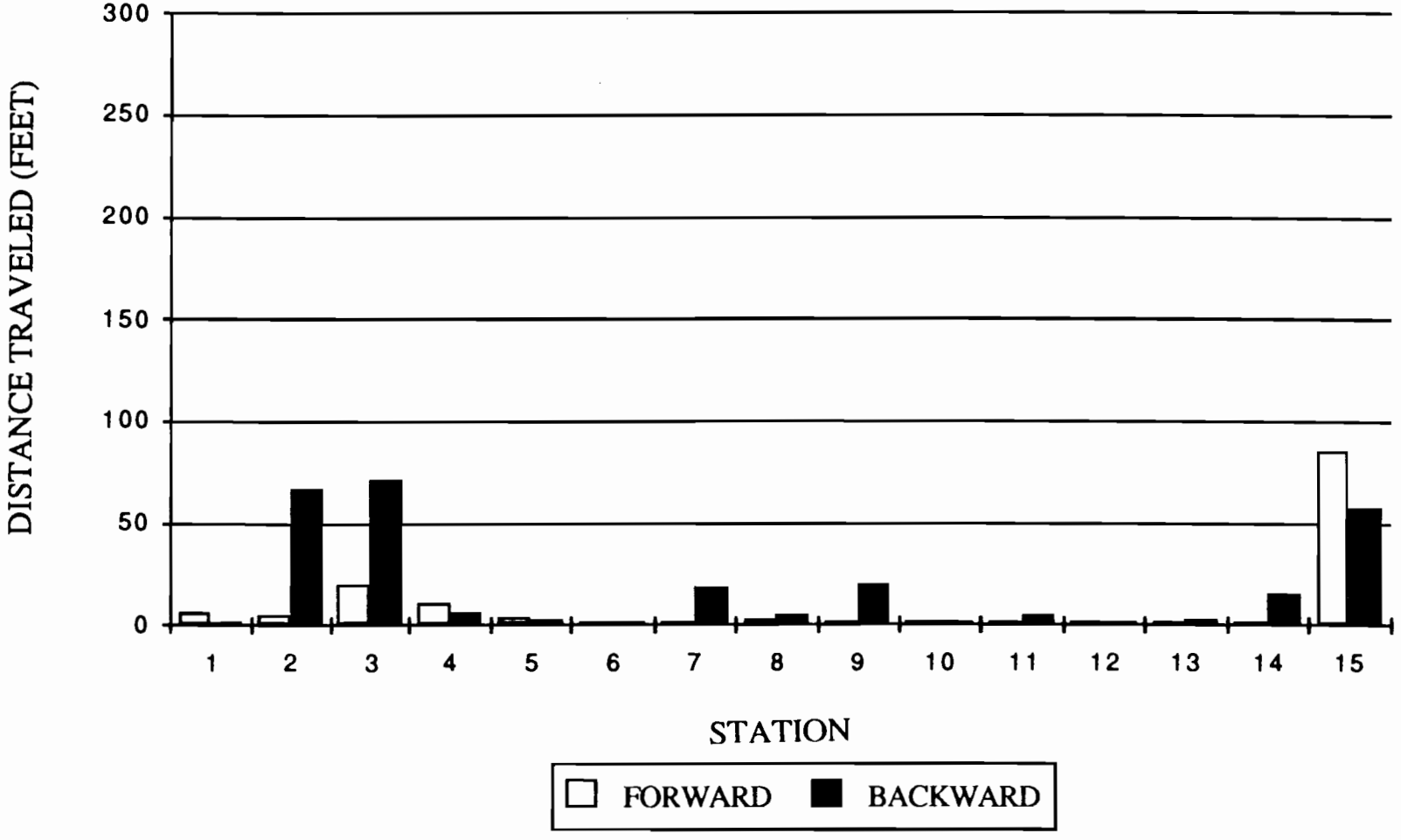


Fig 6.4. Comparison of average distances for rocks in forward and reverse directions

testing; have greater averages in 8 out of 12 stations. Also, three times in backward testing, the average is over 50 feet. This is compared to only once that the average is over 50 feet for the forward testing .

(C) Maximum Distances for Rocks
In testing with rocks and using maximums, forward and backward tests are compared in Fig 6.5. Backward testing has a higher maximum in almost every station. Backward testing also has maximums over 50 feet four times. This is compared to the one time in forward testing in which the maximum is over 50 feet. The greatest maximum in backward testing is 200 feet, nearly three times the greatest maximum found in forward testing. The higher maximums in backward testing for rocks become even clearer if we look at the average of the maximum at each station. The average of these maximums for forward testing is 22.4 feet and for backward testing it is 66.6 feet, or three times that for forward testing.

Thus, in all data for testing with both rocks and blocks in forward and reverse, the conclusion is reached that backward testing causes objects to be thrown farther than does forward testing. Both the data for maximum and average distance traveled support this conclusion.

Comparison of Test Results With and Without Safety Equipment

(A) Average Distances for Blocks
Figure 6.6 allows for the comparison between three tests: (1) with all safety devices, (2) without the cables and (3) without the chains. This figure is a bar chart showing averages at each station for blocks in a forward test. Testing done without chains has the highest averages in 12 out of 15 stations. This test also has the 10 highest averages overall. In addition, the average is 270 feet at station 15 or nearly seven times any average in any of the other tests. Comparing testing done without cables to testing done with all safety devices, it is seen that in 9 stations out of 15 the testing without cables produces a higher overall average of the two tests. Also, the tests without cables have the higher overall average of the two tests (nearly 50 feet).

(B) Maximum Distances for Blocks
The bar chart of Fig 6.7 compares maximum distances traveled in testing done with blocks for the conditions of without cables, without chains, and with all safety devices. Testing without chains has the greatest maximum in 13 of the 15 Stations. It also has seven maximums over 100 feet. In contrast, testing without cables and testing with safety devices has one and zero maximums over 100 feet respectively. Comparing testing done with all safety devices to testing done without cables, it is found that testing with safety devices has the higher maximums of the two tests in seven stations and that testing without cables also has the higher maximums of the two tests in seven stations.

The trends between these tests for blocks can also be seen by looking at the average of the maximums (see Ref 25, Appendix B). In testing done with safety devices, the average of the maximums is 37.5 feet, in testing without cables it is 36.1 feet, and in testing without chains it is 88.8 feet. Thus, in tests using blocks, testing without chains clearly has the highest maximums while testing without cables and testing with all safety devices have about equal maximums.

(C) Distribution of Distances for Blocks
Figure 6.8 is a distribution chart which places each object hit into six distance ranges and gives the percentages of total objects hit in each range. In this figure it is seen that a large percentage of the blocks hit in testing without chains go a long distance. Four percent of the distances

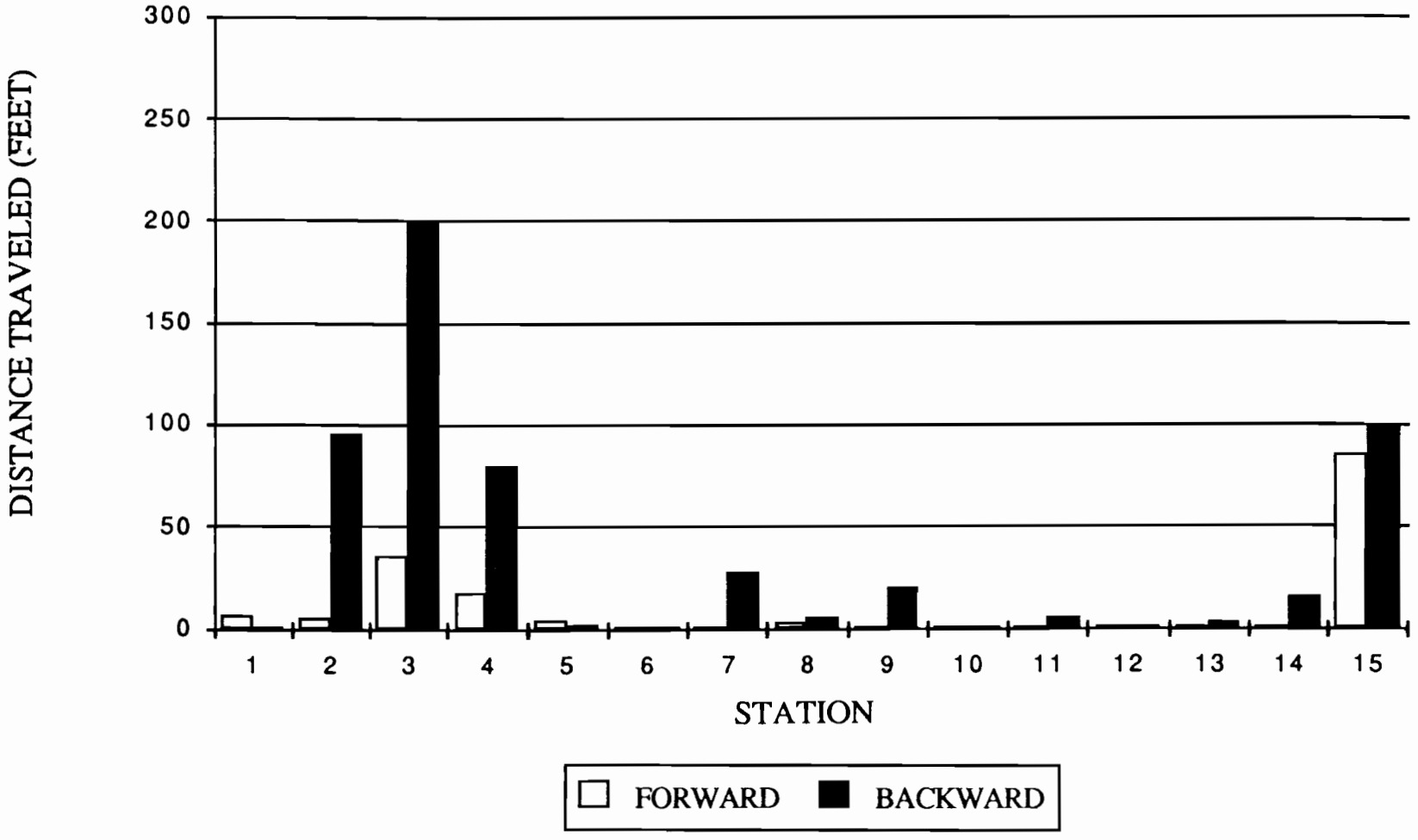


Fig 6.5. Comparison of maximum distances for rocks in forward and reverse directions

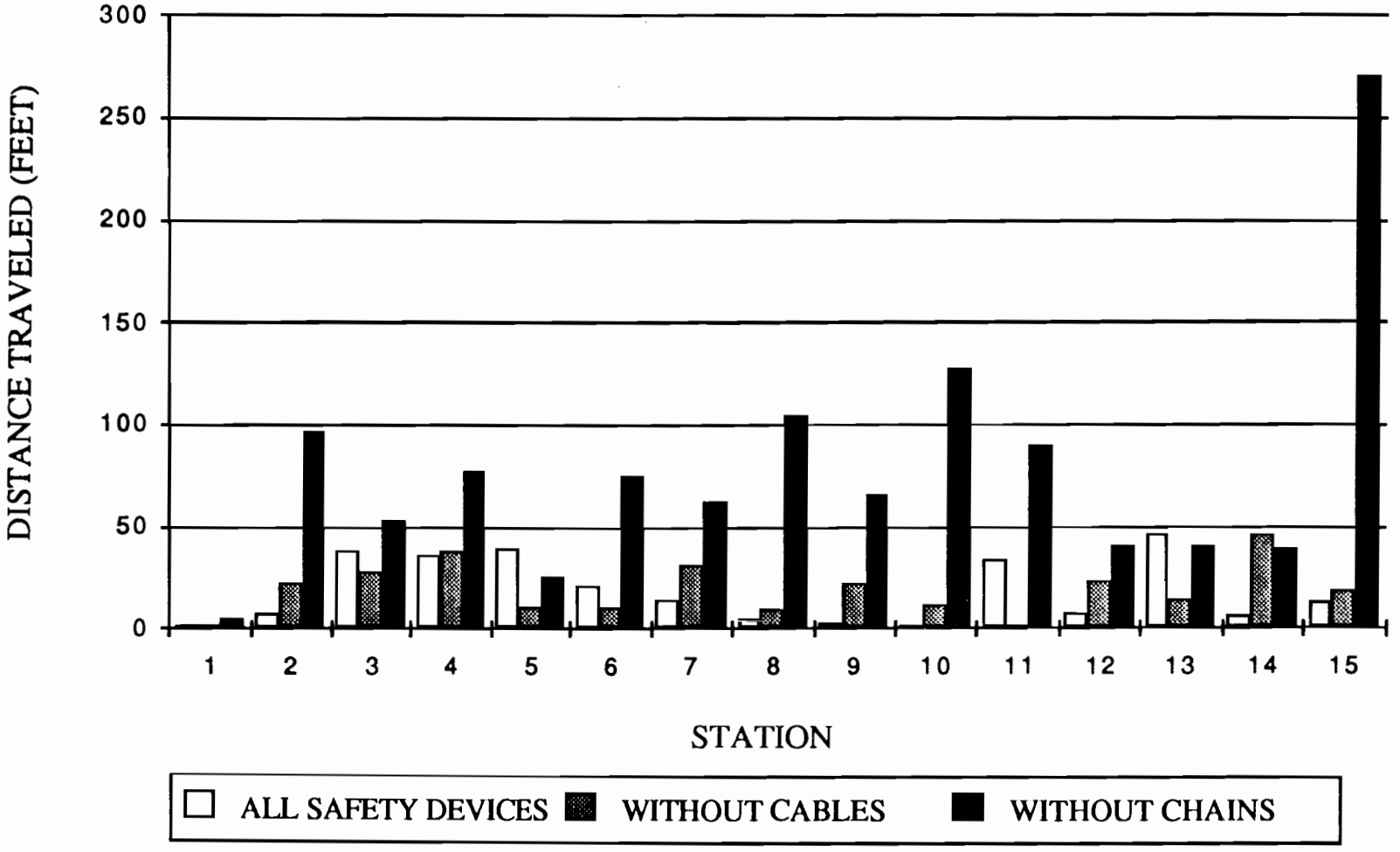


Fig 6.6. Comparison of average distances for blocks in forward direction with various safety devices

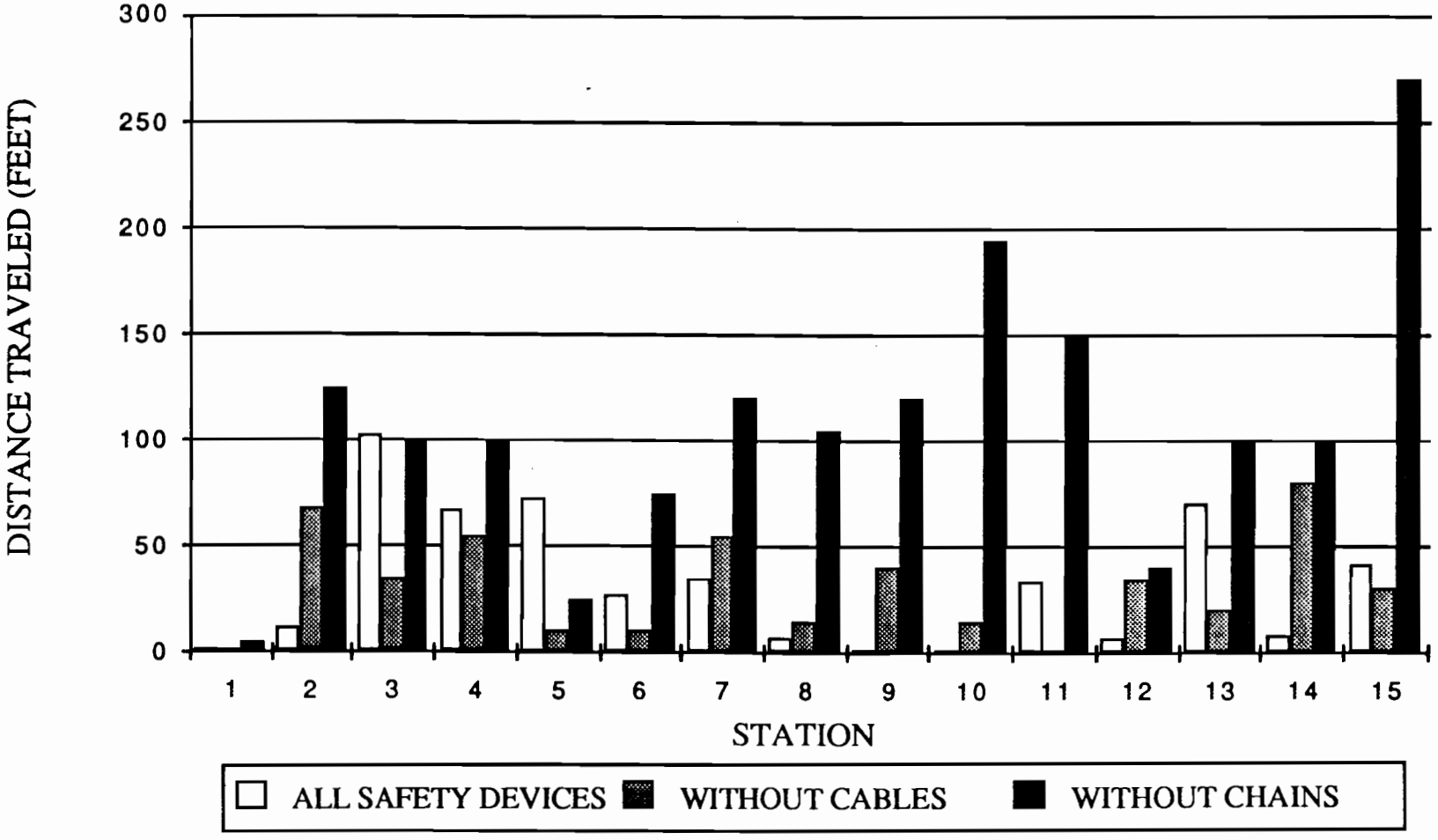


Fig 6.7. Comparison of maximum distances for blocks in forward direction with various safety devices

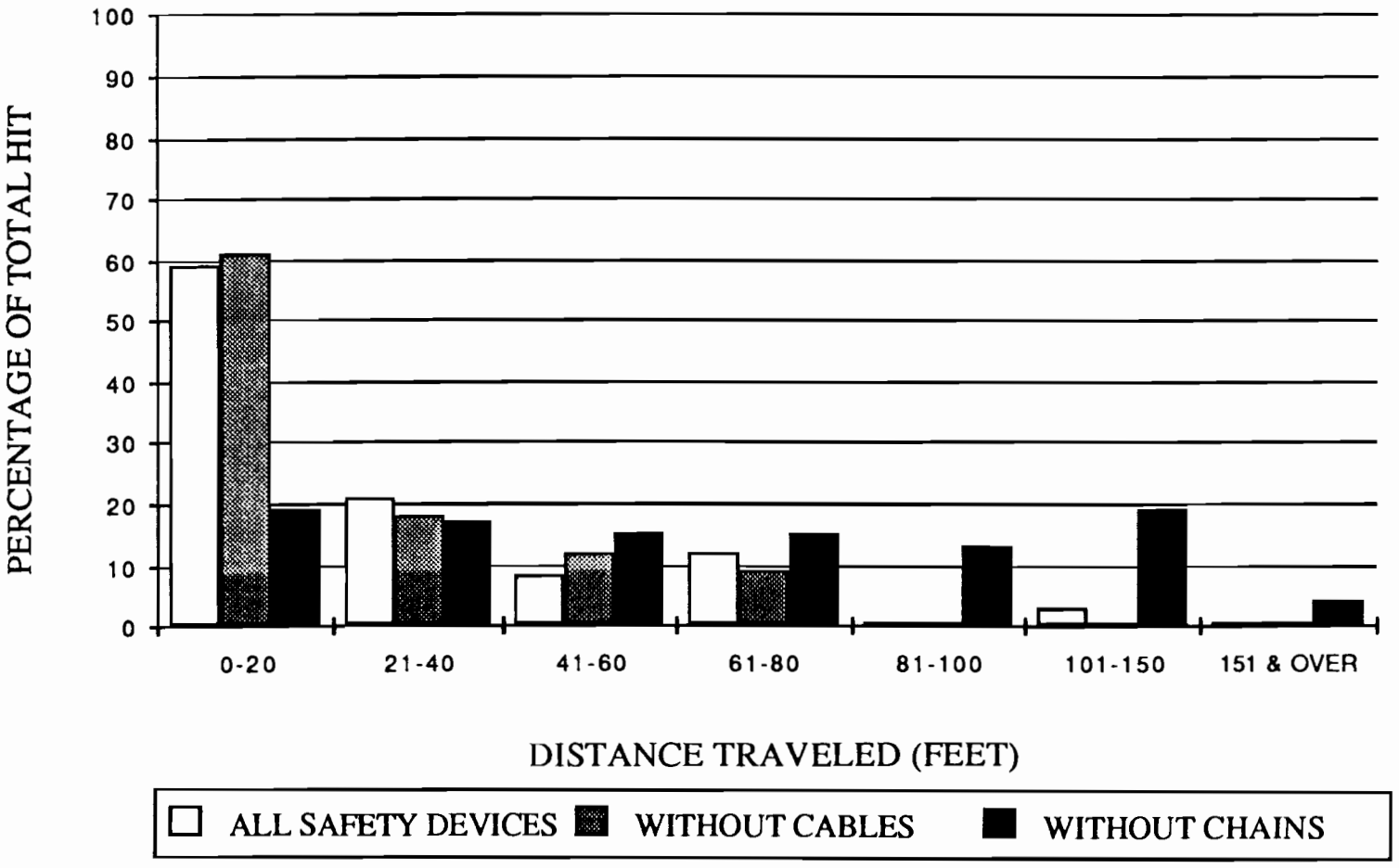


Fig 6.8. Distribution for blocks tested in forward direction with various safety devices

traveled by the blocks in this test are over 151 feet, 23 percent are over 101 feet, and 35 percent are over 81 feet. In comparing this with the travel distances for blocks in testing with all safety devices, it is seen that 3 percent are over 81 feet and none of the distances are over 101 feet. If a comparison is made between testing without cables to testing with safety devices little difference can be seen in percentages of objects hit into each of the six distance ranges.

(D) Average Distances for Rocks

Average distances for testing with rocks are compared in Fig 6.9 for the tests of safety devices used, without cables, and without chains. Testing without chains produces the highest average in 9 of the 13 stations. Furthermore, testing without chains has averages over 50 feet in five stations. This is observed for each of the other tests in only one station each. When comparing averages of testing without cables to testing with safety devices, it is noted that in four stations testing without cables has averages over 20 feet; this is observed in two stations for testing with safety devices.

(E) Maximum Distances for Rocks

The bar graph of Fig 6.10 is a comparison of maximum distances traveled by rocks in each station. Shown in this graph are testing with safety devices, testing without cables, and testing without chains. In 9 of 12 stations in which the averages are non-zero, testing without chains has the greatest maximum. It also has 5 of the 6 overall highest maximums, all of which were over 100 feet. Testing without cables has the highest maximum (250 feet) of the three tests. This maximum is three times the highest maximum in testing with safety devices. However, the testing without cables and the testing with safety devices are equal in the number of stations in which one test has a higher maximum than the other (6 stations to 6 stations).

Once again the average of the maximums at each station is computed to gain a clearer perspective in comparing the maximums. For testing with rocks the average of the maximums is 22.4 feet when all safety devices are used, 75.0 feet when cables are not used, and 116.1 feet when chains are not used (see Ref 25, Appendix B). Therefore, the test without chains consistently produces the highest maximums. In addition, testing without cables produces higher averages of the maximums than does testing with the safety devices due to the unusually high maximum of station 10.

(F) Distribution of Distances for Rocks

Figure 6.11 groups each object hit into ranges based on distances traveled and shows the percentage of the total hit which fall into each range. Overall, it is seen that in testing rocks without chains, 24 percent traveled over 101 feet and 68 percent traveled beyond 40 feet. This is to be compared with 0 percent beyond 101 feet and 10 percent beyond 40 feet in testing with safety devices, and 8 percent over both 40 feet and 100 feet for testing without cables. It is seen that nearly 10 percent of the rocks thrown in testing without cables travel beyond 51 feet, while none of the rocks travel this distance in testing with safety devices. Also 33 percent of the rocks in testing without cables traveled between 21 and 40 feet; whereas, only 10 percent in the testing with safety devices fell into this range.

In summary, all testing done with rocks and blocks give the result that operation of the mower without chains will produce the longest object travel. This is supported by maximum distances, average distances, and by the distance distribution. However, the distinction between using the cables during operation and not using them is not as clear. For block testing, the results from maximum distances and the distance distribution allows the conclusion that there is virtually no difference between using and not using the cables. However, for blocks there is a slight increase

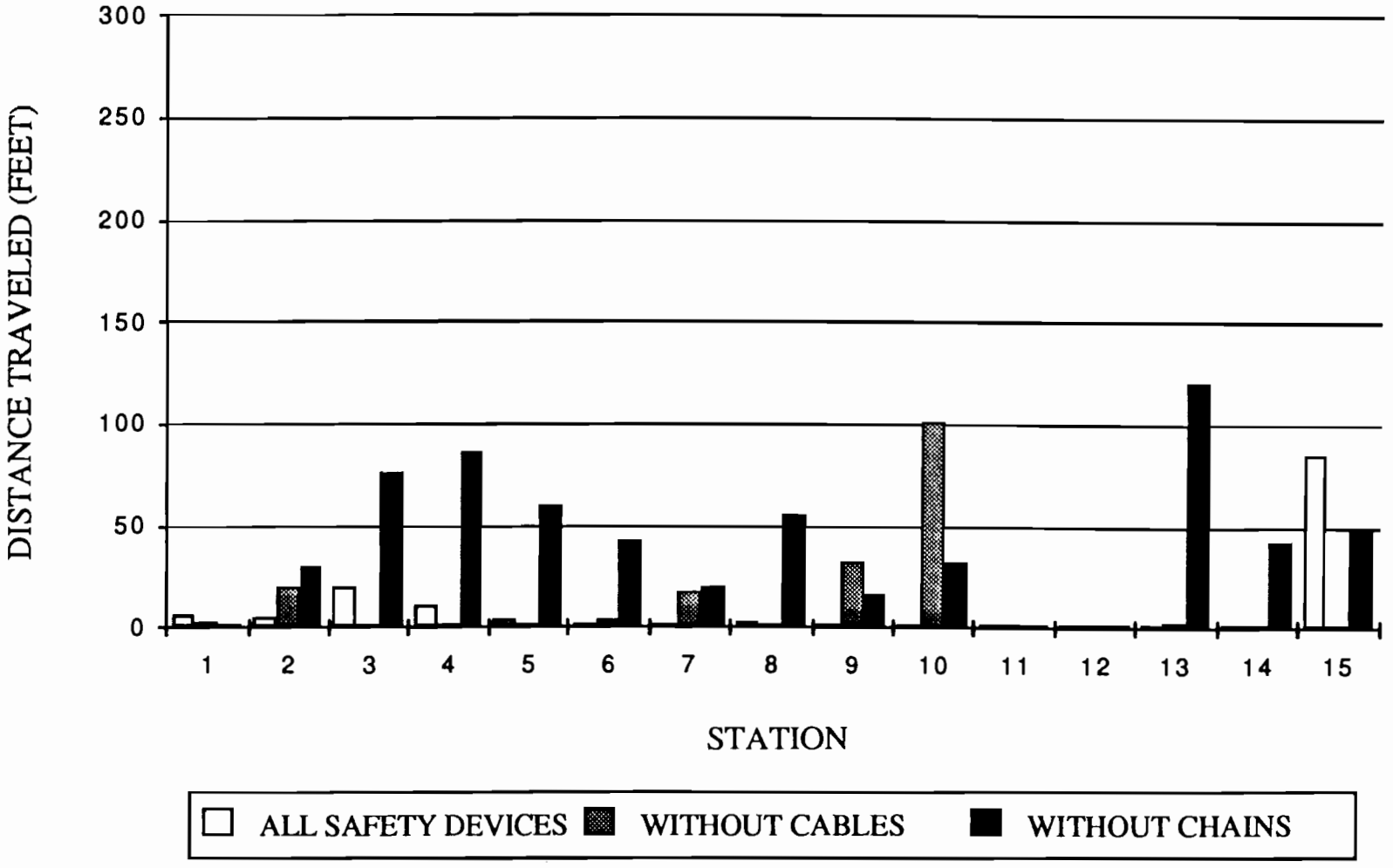


Fig 6.9. Comparison of average distances for rocks in forward direction with various safety devices

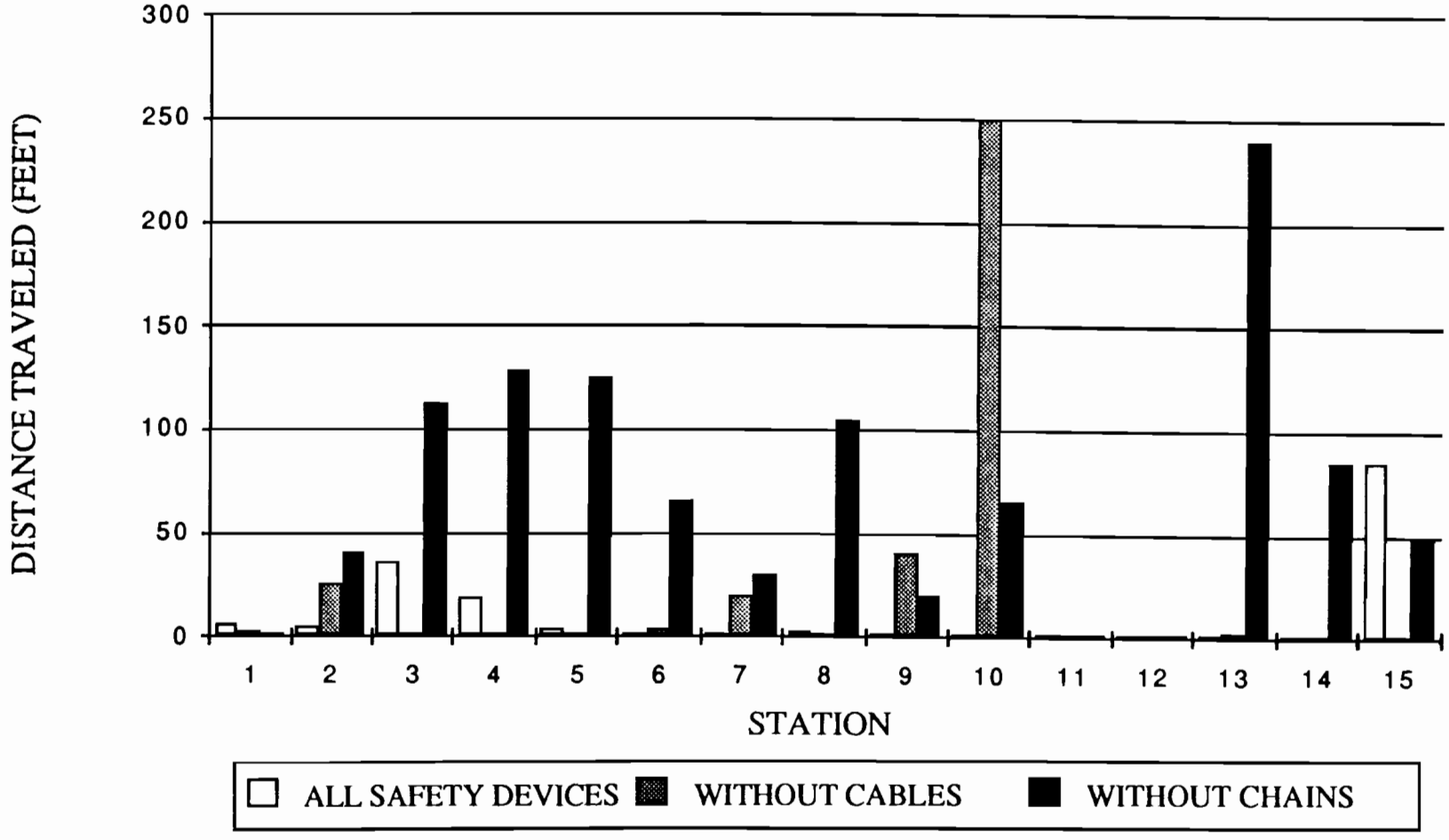


Fig 6.10. Comparison of maximum distances for rocks in forward direction with various safety devices

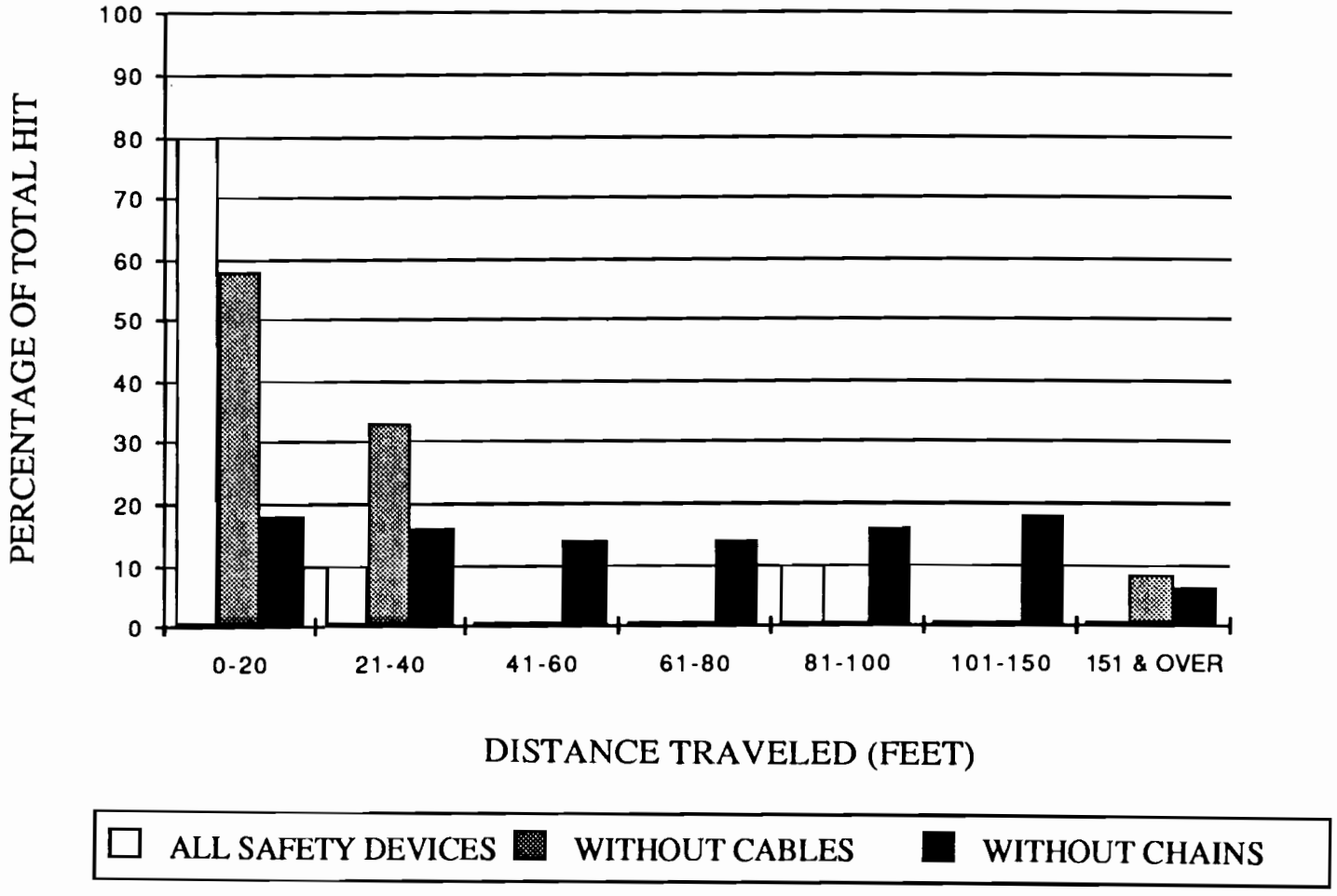


Fig 6.11. Distribution for rocks tested in forward direction with various safety devices

in average distance when the cables are not used. For rock testing average distances and maximums distances are slightly greater in testing without cables. The distance distribution also supports the conclusion that rocks travel slightly farther without the cables than with the cables.

PROCESSED DIRECTION DATA

For each test the direction of object travel was taken with its distance and made into a vector. These vectors are placed at the object starting point in each station. All of the vectors in each test are combined into a vector diagram. The outline of the mower is superimposed over the origin of each vector so that an estimate of the exit point can be made. The length of the vectors do not necessarily represent the actual distance traveled. In order to present the diagrams many longer vectors are not shown to true length.

Vector diagrams are shown in Fig 6.12 and 6.13 for the base test which is the forward test with all safety devices. The test with rocks has few objects exiting the mower but the objects exit out the rear sections near the wheels (see Fig 6.12). The tests with blocks have many objects exiting the mower and once again most exit out the rear near the wheels (see Fig 6.13).

The pie charts of Fig 6.14 and 6.15 allow for the numerical analysis of the vector diagrams. In Fig 6.14 rock test results are examined. Here 70 percent of the rocks exit the rear sections of the mower, 30 percent of these out the rear right and 40 percent out the rear left. Fig 6.15 is a chart of block test results, from which it is found that 74 percent of the objects exit the rear of the mower, 33.3 percent exited the left while 51.3 percent exit the right rear of the mower. Also 62 percent exit the right side of the mower with only 38 percent exiting the left side. Therefore, most objects exit the rear sections of the mower and more objects exit the right side than the left side of the mower.

Vector diagrams of tests without cables emphasizes the trend that more of the objects exit the rear of the mower than the front and that more objects exit the right side of the mower than the left side . However, when chains were taken off the mower many more objects exited the front sections of the mower.

OBSERVABLE EVIDENCE

Under certain terrain conditions the chains and side skirts are no longer close to the ground. Therefore, objects can exit through these openings undeflected. This occurs when the wings are not level with the rest of the mower and when the mower is operated along an incline. On a negative slope the side skirt can be lifted away from the ground leaving an opening (see Fig 6.16). The chains can be raised off the ground when a wing is on a positive slope (see Fig 6.17). Also, when the mower travels along an incline the chains can swing to one side revealing an opening (see Fig 6.18).

Although numerical data is not obtained for testing the movement of wings due to problems of consistency in testing, this situation was observed in informal testing. It is noted that as the wings are lowered when the blade is in gear the chances of hitting an object on the ground under the wing seem to increase. This happens when the blade hits an object before the wing and its chains are completely lowered. Similarly, if mowing is done with one wing in the upward position, the other blades can hit an object sending it out the side of the raised wing.

DISCUSSION OF RESULTS

The results of the tests performed show that the safety devices (chains, cables, skirts, etc.) on current mowers are effective in normal use. The mower, when used properly and with care, is

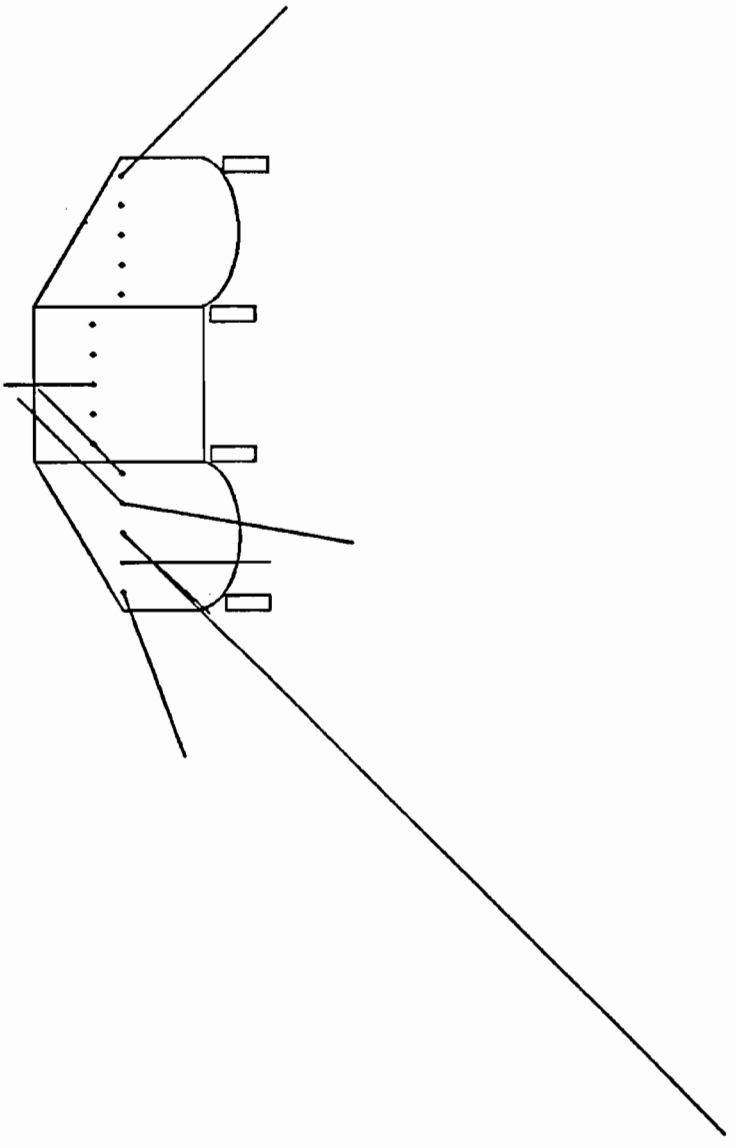


Fig 6.12. Vector diagram for testing with safety devices and rocks (forward)

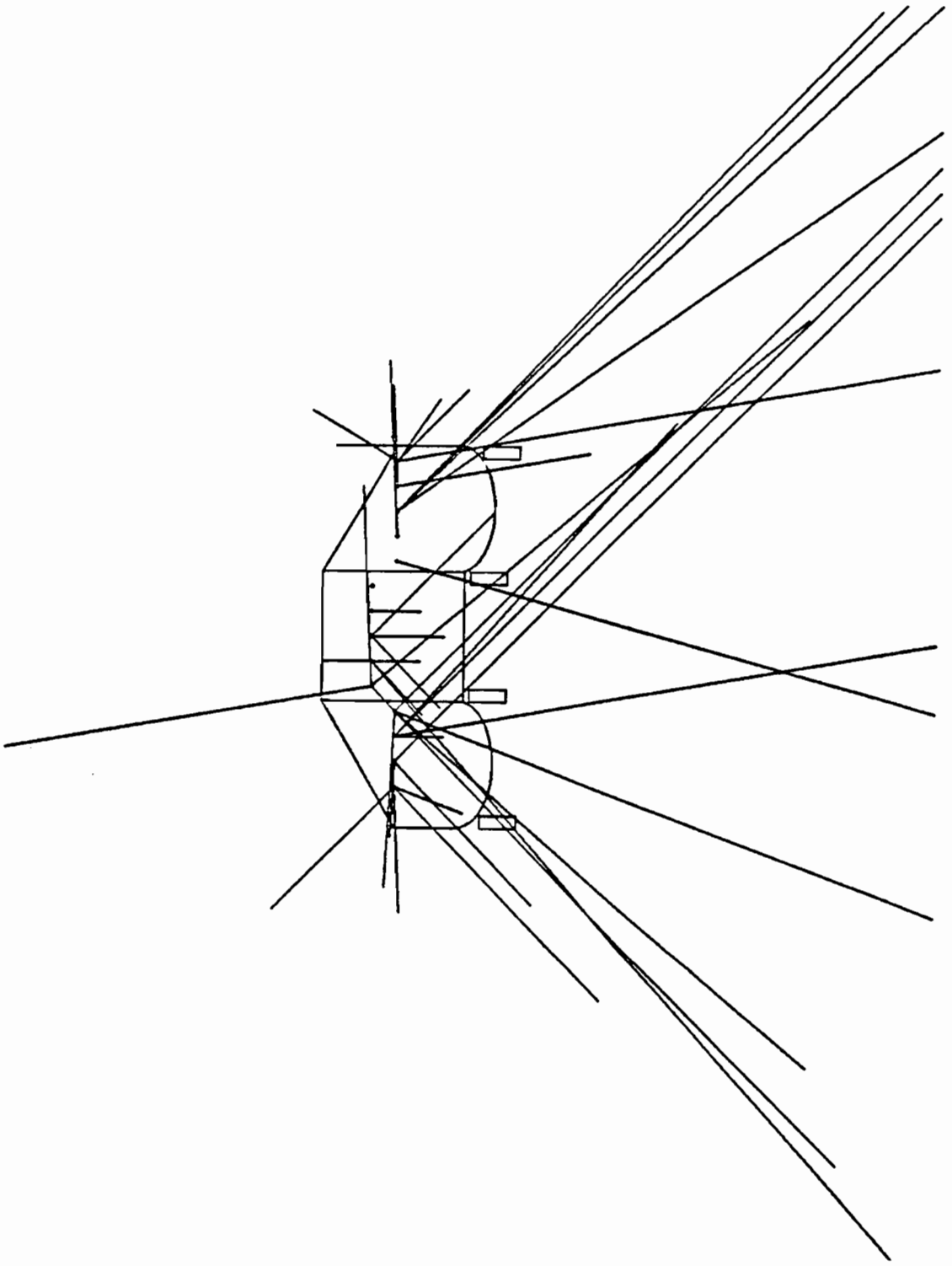


Fig 6.13. Vector diagram for testing with safety devices and blocks (forward)

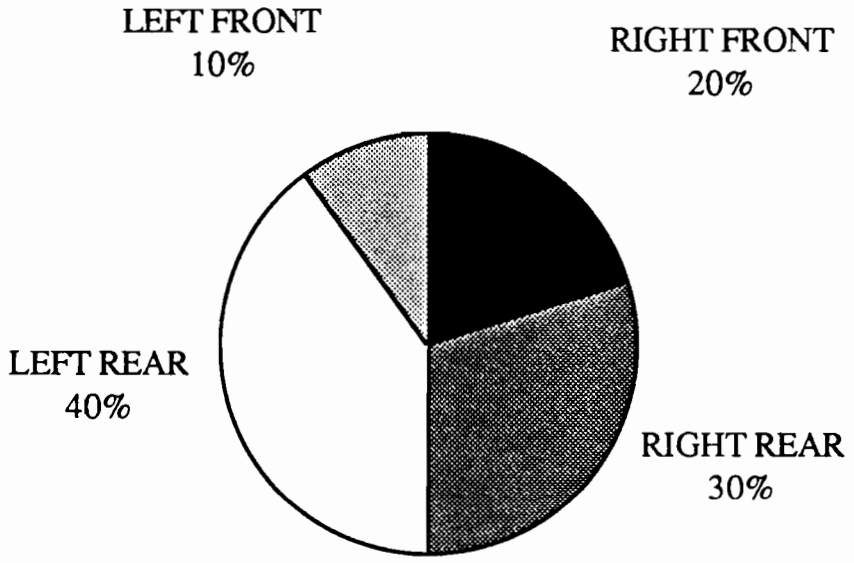


Fig 6.14. Percentage of rocks exiting the mower in each direction for testing with safety devices (forward)

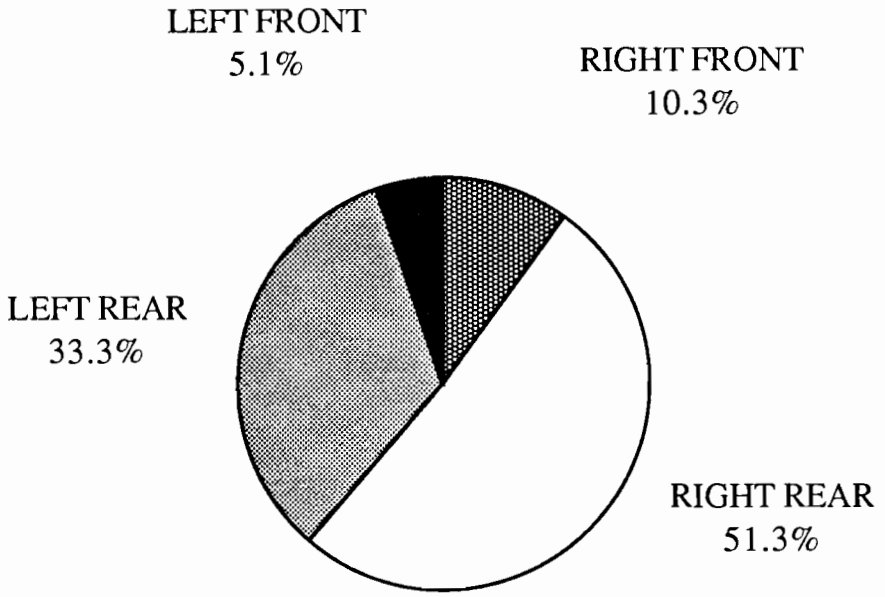


Fig 6.15. Percentage of blocks exiting the mower in each direction for testing with safety devices (forward)

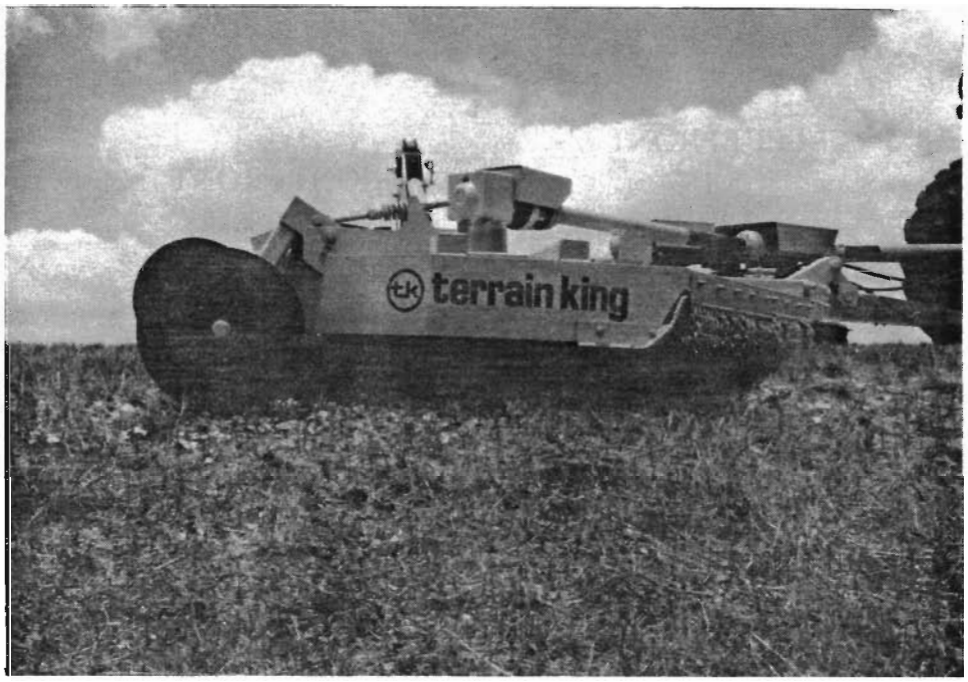


Fig 6.16. Hazardous gaps created when mowing on a negative slope

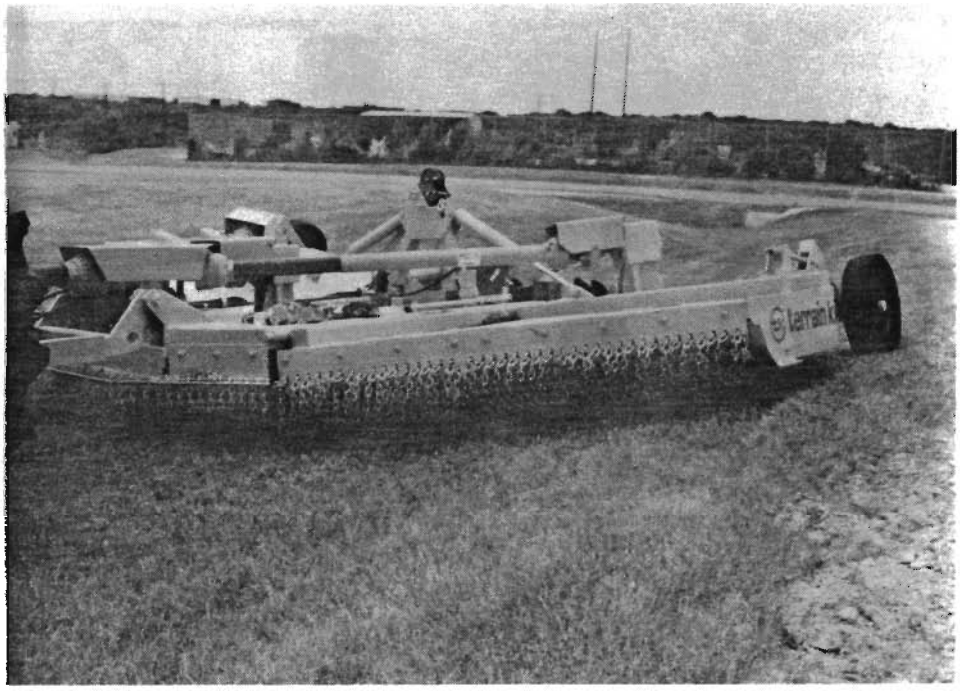


Fig 6.17. Hazardous gaps created when mowing on a positive slope

Fig 6.18. Hazardous gaps created when mowing on an incline

relatively safe. However, the safety devices cannot stop every object from being thrown from the mower. Under certain conditions the mower is more likely to throw an object.

When used in a forward direction the mower tends to throw objects out to the back of the mower. This is mainly due to the way in which the cutting height is set for the mower. The height of the rear of the mower is set 1 inch higher than the front. The resulting angle tends to force the objects that are hit forward, down slightly so that the chains are more effective in deflecting them to the ground. Also, objects hit forward may get hit again and finally end up going out the back of the mower.

The chains around the mower are held by chain guards (see Fig 6.19). The chain guards are solid down to about the level of the blades. The chains are attached below this point. When objects are thrown forward by one of the blades, the chain guards tend to either deflect it down or backward into the mower. This prevents most objects from being thrown forward and serves to crush larger objects by repeatedly subjecting them to the impact of the blades. A comparison of the tests performed with chains and those without shows that without both chains and chain guards, many objects will be thrown forward. Also, the objects thrown in these tests were very large. Sometimes the entire rock or block was thrown. This shows the effectiveness of the front chain guards and chains in preventing objects from exiting this area.

Of the objects leaving the rear of the mower, most tend to exit to the right side. The direction of rotation of the blades is responsible for this. The left and center blades rotate counterclockwise, therefore objects hit to the rear of the mower are thrown to the right (see Fig 6.20). The clockwise rotation of the blade on the right will tend to throw objects left but the number of objects thrown from the left blade is less than from the other two (see Fig 6.13). Without chains, the center and left blades tend to throw the object to the left if the object exits the front (see Fig 6.21). Similarly, the right blade will throw objects to the right if they leave the front (see Fig 6.22).

One of the safety devices used on mowers is running cables through a lower link in the chains (see Fig 5.3). The test results do not show a significant effect in reducing the distance a lighter weight object (wood) is thrown. Objects much less massive than the chains are not effected much by the use of the cables. The cables do seem effective in reducing the distance a heavy object (rock) is thrown. The cables help the chains act as a curtain and increases the effective mass of the chains. The amount of data obtained was small, so the tests do not show its effect conclusively. Data was difficult to collect when cables were used because the cables tended to push most movable objects out of the way thus keeping them from getting under the mower.

When the terrain is such that the wings of the mower are not horizontal, mowing can be dangerous. Under these conditions the chains and side skirts do not always stay close to the ground (see Fig 6.16, 6.17, 6.18). When this occurs, an object can easily leave the mower through one of these open areas.

Another dangerous condition is that of raising and lowering the wings during mowing. This becomes dangerous for two reasons. If the wing is in the upward position, the side guard and chain guards are also raised off the ground on this side leaving a large gap for objects to escape the mower. The blade may also hit objects as it is lowered before the side and chain guards reach the ground.

The tests also show that operation of the mower while backing is a dangerous condition. Objects are thrown farther when the mower is used in a backward direction than when it is pulled forward. Objects that enter the mower from the back tend to exit the mower immediately after being hit because the back is higher than the front providing less resistance to the object's flight.

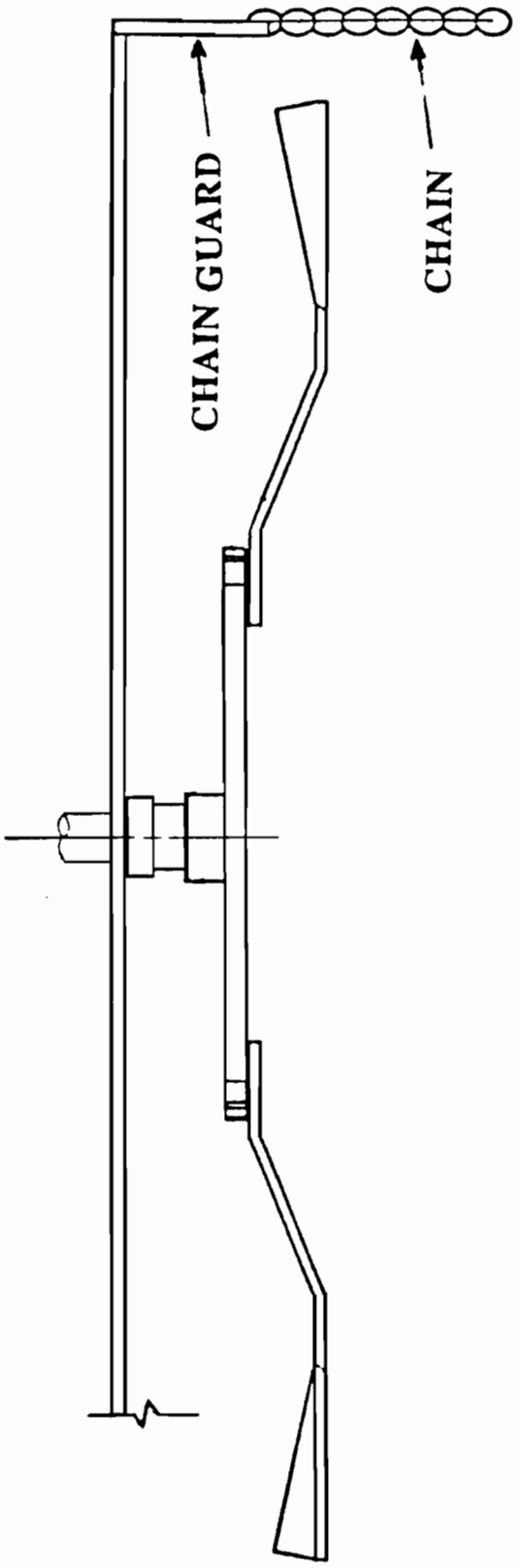


Fig 6.19. Relationship of blades to chains and guards

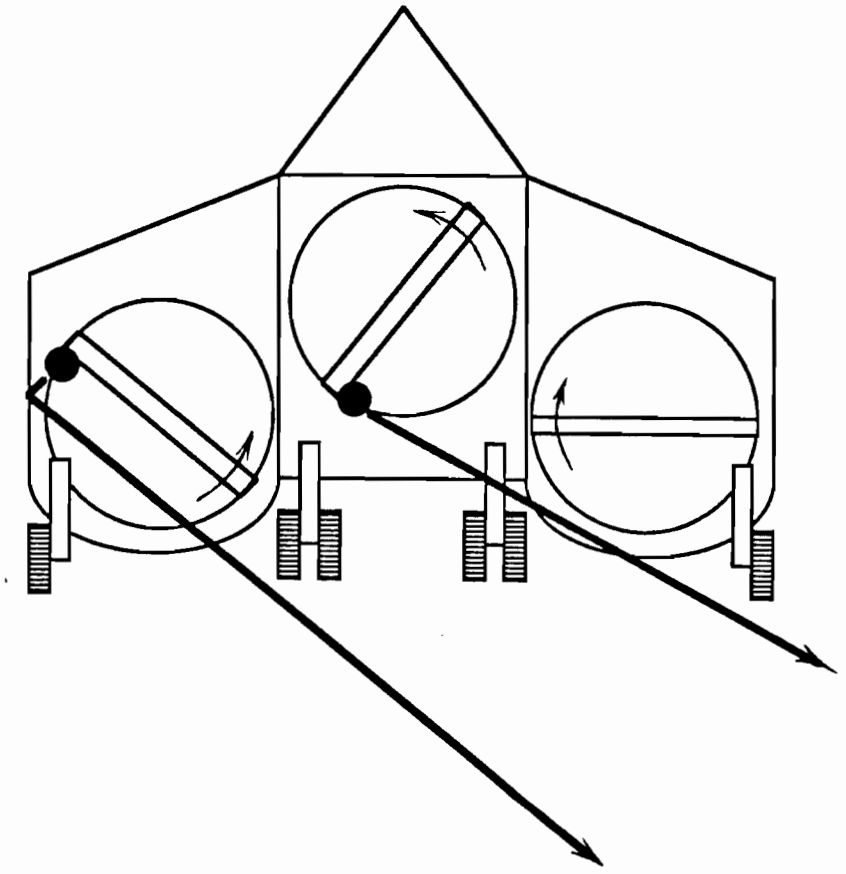


Fig 6.20. Relationship between rotation of left and center blades and direction of objects exiting mower

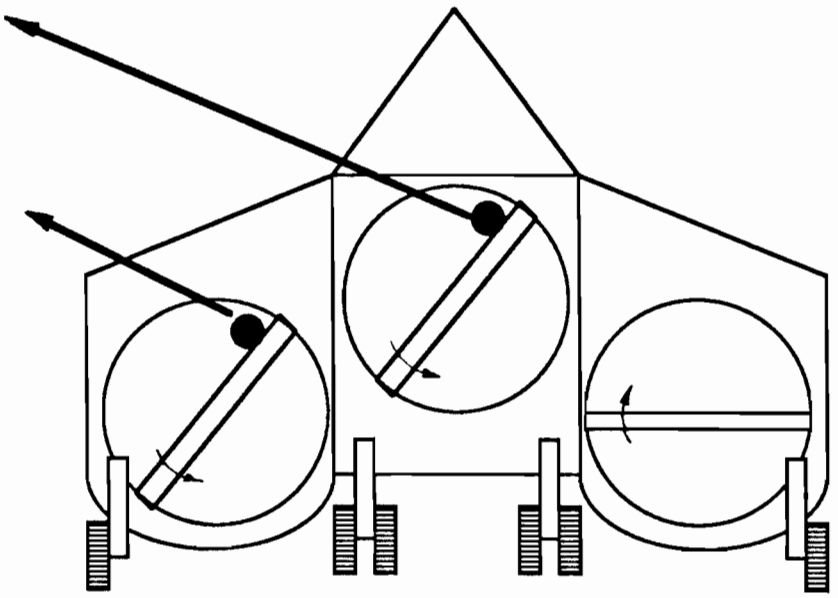


Fig 6.21. Relationship between rotation of left and center blades and direction of objects exiting mower without safety devices

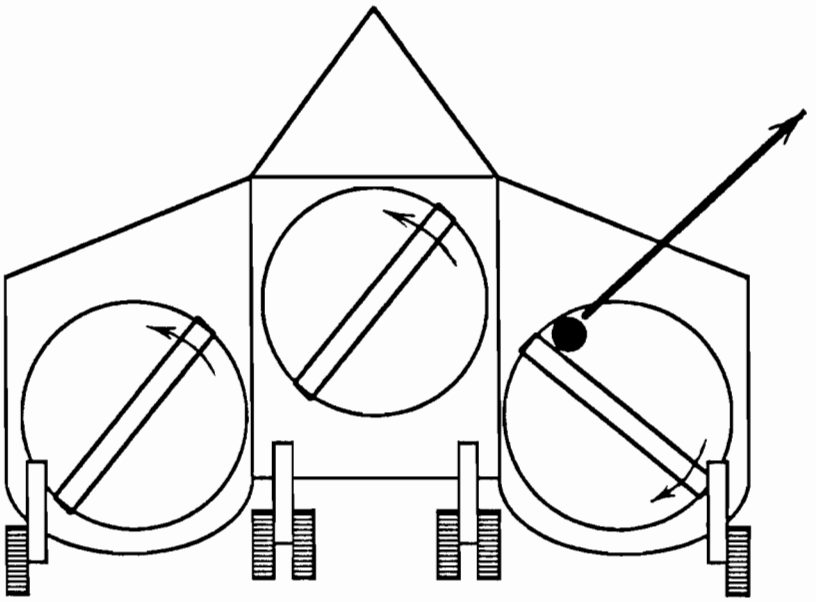


Fig 6.22. Relationship between rotation of right blade and direction of objects exiting mower without safety devices

CHAPTER 7. CONCLUSIONS AND RECOMMENDATIONS

Based on the work discussed in the previous chapters this chapter presents the conclusions made by the authors and makes recommendations for reduction of mower thrown object accidents. Recommendations for future work are also presented. The conclusions and recommendations are categorized under (A) alternative mowing equipment, (B) changes to mowing standards and (C) modifications to the bat-wing rotary mower (Terrain King).

ALTERNATIVE MOWING EQUIPMENT

1. Accident data analysis has shown that rotary mowers are the worst offenders as far as the MTO problem is concerned and hence other mowers or chemical control must be deployed instead in high risk areas.

2. The rotary disc mower being used by the Minnesota State Highway Department has shown promising results as far as productivity is concerned. The discs and the cutting elements have much lower moments of inertia than the cutting bar blades of the rotary mowers. The analysis of blade-object impact has showed that a reduction in the moment of inertia of the blade reduces the M.T.O. discharge velocity. Therefore the rotary disc should be a safer mower from a M.T.O. view point. Furthermore the Minnesota State Highway Department has stated (details in Ref 10) that the disc mower causes less M.T.O. accidents than the flail and rotary mowers and surpasses the flail and rotary mowers in productivity. Thus, the rotary disc mower, with the combination of higher productivity and safer operation offers an attractive alternative to the rotary blade mower.

CHANGES TO MOWING STANDARDS

1. Nearly all the changes made in the past on rotary mowers (garden type) have been a modification in the blade or the housing. However, most states have reported to SDHPT in their reponse to inquiry by SDHPT that they regard the height of cut as a major contributing factor to MTO accidents. Furthermore the states have reported that the operators tend to reduce the height of cut in the field. With a reduction in the height of cut, smaller debris that would have otherwise escaped the rotating blade, will now be struck by the mower blade and discharged. Specifying a greater height of cut of around 6 inches, possibly aided by a mechanism that flashes a warning light when the blade comes into contact with an object other than grass could be useful; a better method of height adjustment is being considered by engineers at Terrain King.

2. Field experiments with the Terrain King rotary mower (Chapter 6) show that the majority of the debris exits the right side rear of the mower and thus makes this area extremely dangerous. It is recommended that tractor/mower drivers be made aware of this danger zone so they avoid placing co-workers or the public in this area. In addition, mowers should be orientated so they move against traffic. Statistics show that this is the safest way to mow. In this configuration, the motorist and any M.T.O. will be traveling in the same direction, so the impact velocity from the M.T.O. is lessened. Mowing against traffic may not always be possible, but should be practiced for the first two passes along the roadside.

3. It is found from field experiments that mowing without safety chains is significantly more dangerous than mowing with them, and that mowing without the cables that are strung through safety chains is slightly more dangerous than mowing with them. Hence, existing mowers owned by the SDHPT should be maintained or upgraded to the standards used for purchasing new mowers. Further, it is recommended that the field experiments designed in Chapter 5 be adopted as a tentative standard for testing and evaluating future mower acquisitions.

4. It was observed during field tests that mowers encounter certain dangerous conditions due to the terrain. These conditions cause gaps to occur in or below the chains, thus leaving easy openings for objects to exit. Terrain that causes these conditions to occur should be identified to tractor drivers so they know when to exercise extra caution in mowing. Extra caution should also be exercised when mowing backward or with the wings raised. Field testing has shown backward mowing to be slightly more dangerous than forward mowing and that dangerous conditions are created by mowing with the wings raised or as they are moved up or down. These results have of course, been obtained from tests with a Terrain King mower and their general applicability must be determined after further testing.

MODIFICATIONS TO BAT-WING ROTARY MOWER (TERRAIN KING)

1. Analysis of the blade-object impact phenomenon (Ref 1) has shown that a reduced mass blade can reduce the momentum transferred to M.T.O.'s. Field experiments with various blade materials and geometries (Ref 26) has shown that this is indeed so with a shortened blade made of steel or a lighter material (Aluminum, Kevlar reinforced epoxy) (see Fig 7.1). Futher testing would be required to determine grass cutting effectiveness and blade life.

2. Field experiments having shown that safety chains are fairly effective in guarding exists from M.T.O.'s. It is recommended that an additional row of protection to the back of the mower offset behind the chains be provided. This is recommended due to the high number of objects which exit from that area. This second row could be made of canvas and stretched to drape over bars holding it away from the chains or another row of chains could be extended with these bars (see Fig 7.2). These ideas still need to tested and evaluated.

3. The duct and baffle design ideas (Ref 2 and 24) also seem promising. It is recommended that further tests be performed using baffles and ducts with an actual mower (see Fig 7.3). An additional test which could also prove beneficial is to try the same experimental procedures on a similar mower with opposite wing blade rotations (see Fig 7.4). Results should show if one rotation direction is safer than another.

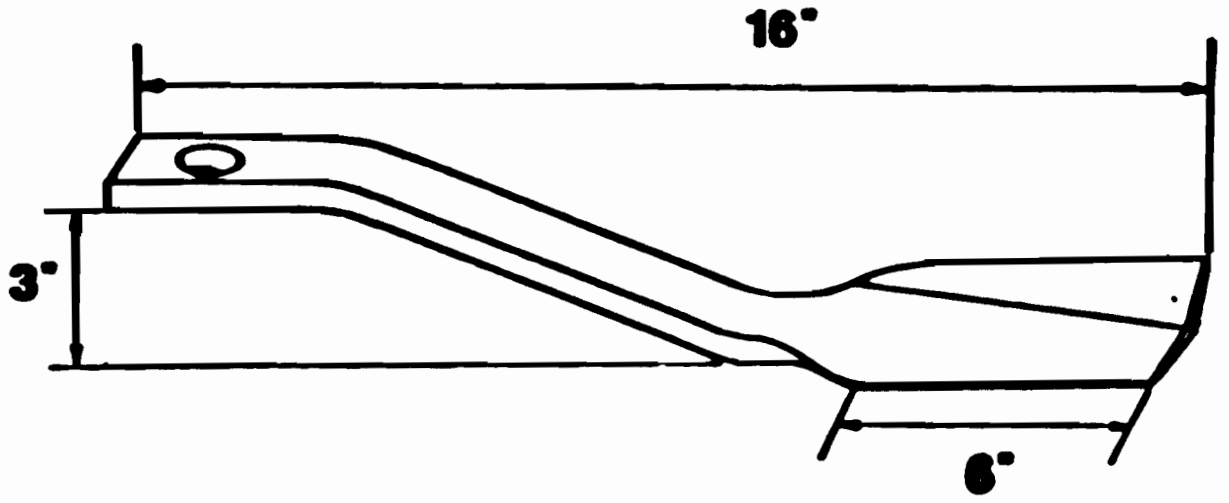


Fig 7.1. Shortened steel blade geometry

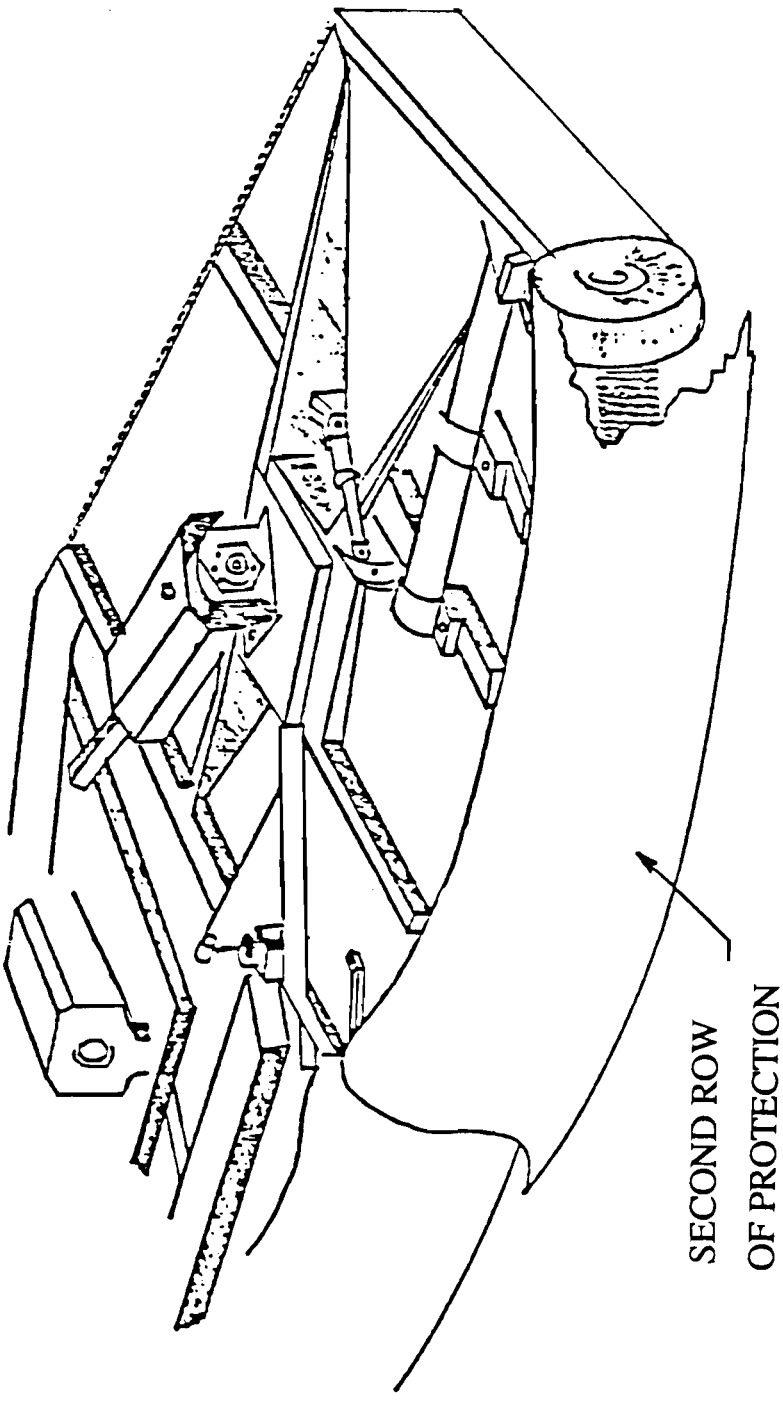


Fig 7.2. Additional protective equipment for back of mower

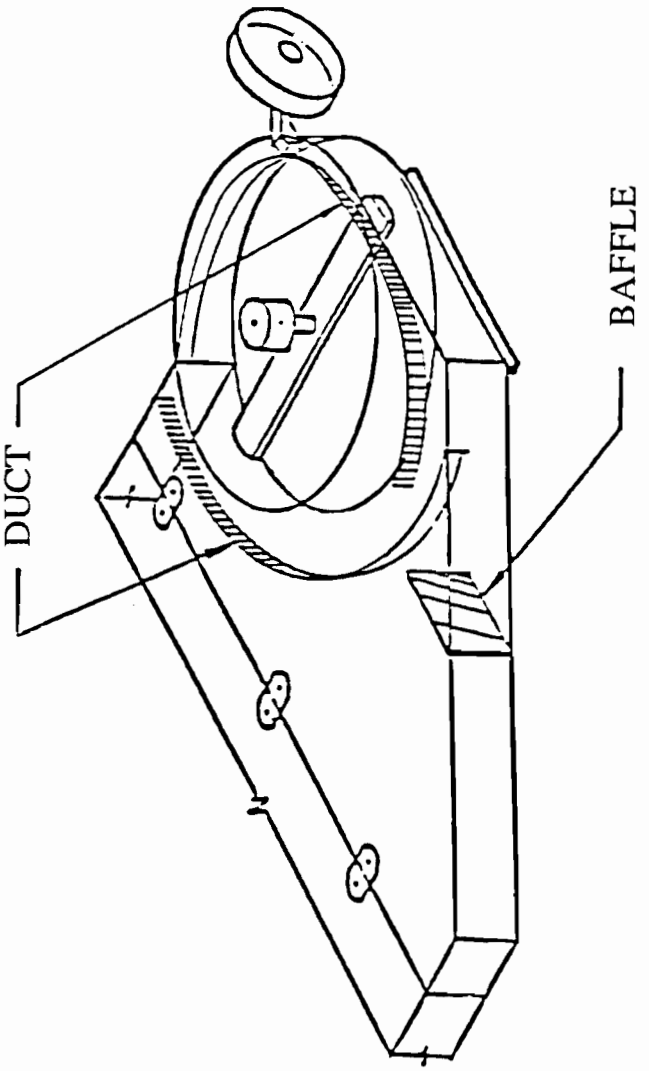


Fig 7.3. Mower with baffles and ducts

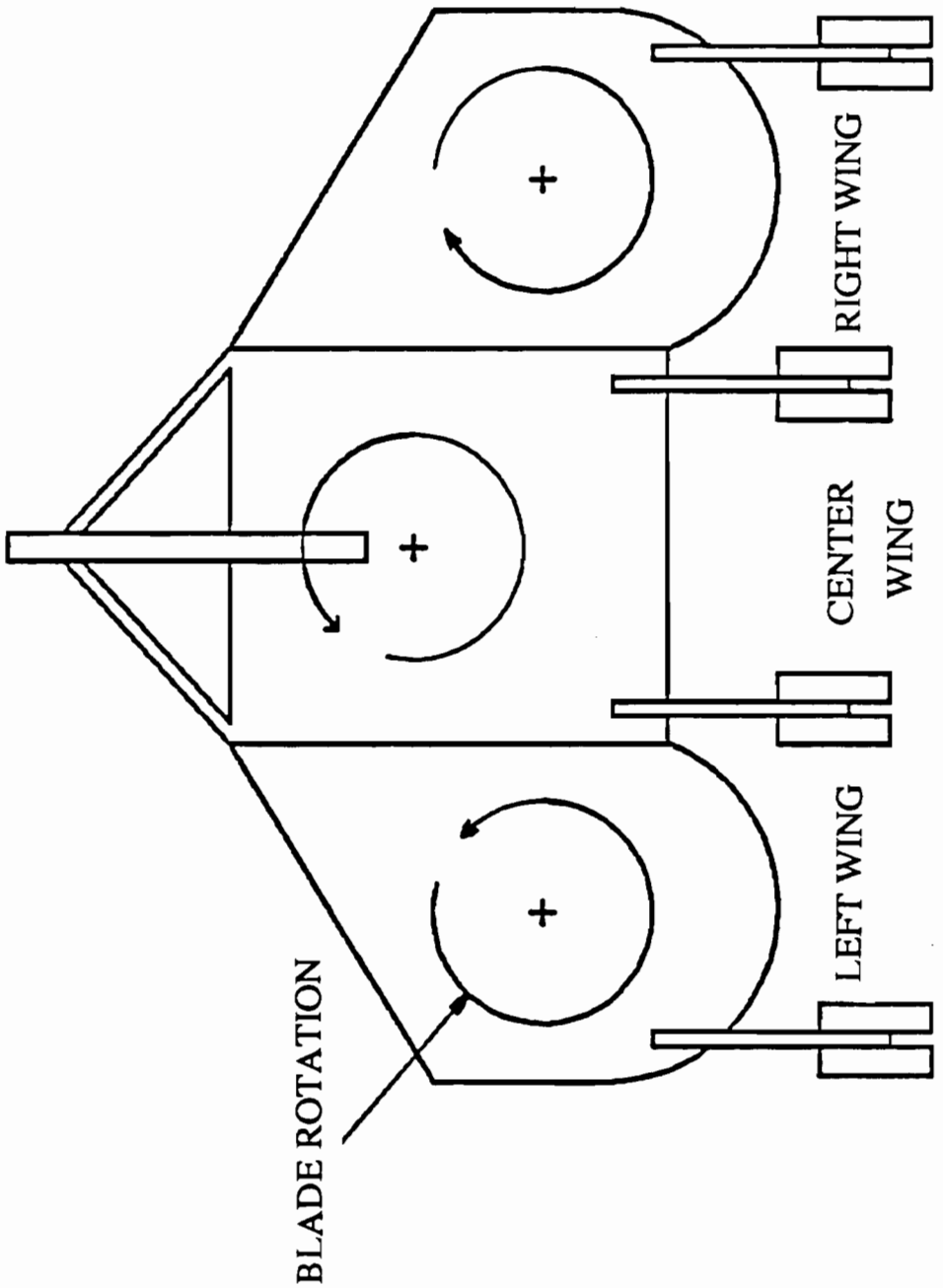


Fig 7.4. Rotation of blades for mower

REFERENCES

1. DaSilva, R. E., Marshek, K. M., and Kannapan, S. K., "An Experimental and Analytical Investigation of Mower-Thrown-Object Phenomena," Research Report. 445-1, Center for Transportation Research, The University of Texas at Austin, August, 1986.
2. Peng, Tsen-loong, Lu, Sao-Dung, Rao, Lei, "Design and Recommendation for the Reduction of Flex-Wing Mower-Thrown-Object Accidents, Mechanical Engineering Design Project Report, Department of Mechanical Engineering, The University of Texas at Austin, Fall, 1985.
3. Sampson, J., "Maintenance Peer Review Committee Report on Mowing and Vegetation", Minnesota DOT, December, 1983.
4. Baker, W., Letter in response to (Ref 11), Delaware DOT, Dover, Delaware, September 6, 1984.
5. Chancellor, W., "Cutting of Biological Materials", University of Southern California, Davis.
6. Hall R. F., Letter in response to (Ref 11), ref: File 1240, Kansas DOT, Topeka, Kansas, December 11, 1984.
7. Woods Division of Hesston Corporation, "Sales Manual, FM 72 Flail Mower", ref:F-6405.
8. Thorud, R., "Development and Testing of a Safer Rotary Lawnmower", *Journal of Safety Research*, vol 3, no. 2, June, 1971.
9. Vicon Disc Mowers, ref: CM 135-165-216-240.
10. Houliston, H., Letter in response to (Ref 11), Minnesota DOT, St. Paul, Minnesota, November 5, 1984.
11. Williams, Q., Letter ref: File no. D-20 3-126.1, Insurance Division, Texas State Department of Highway and Public Transportation. This letter was sent out to various states to determine new or modified equipment that has been successful in reducing MTO accidents.
12. Terrain King Corp., " TK-15HD Owner's Manual, Seguin, Texas.
13. Knapp, L. W., McConnell, W. H., "Epidemiology of Rotary Power Lawn Mower Injuries", Institute of Agricultural Medicine, Bulletin no. 9, University of Iowa, 1965.
14. Moberly, G. E., Letter in response to (Ref 11), Illinois DOT, Springfield, Illinois,

August 28, 1984.

15. Wilkins, C. D., Letter in response to (Ref 11), North Carolina DOT, Raleigh, North Carolina, November 5, 1984.
16. Ortgies, B. H., Letter in response to (Ref 11), ref: 0-20 3-126.1 600, Iowa DOT, Ames, Iowa, October 31, 1984.
17. Kenison, L. S., Letter in response to (Ref 11), Department of Public Works and Highways, New Hampshire, October 26, 1984.
18. Morse, D. H., Letter in response to (Ref 11), Idaho DOT, Boise, Idaho, October 31, 1984.
19. Fulford, M., Letter in response to (Ref 11), New Jersey DOT, Trenton, New Jersey, November 7, 1984.
20. Kuenzli, R. W., Letter in response to (Ref 11), Oregon DOT, Salem, Oregon, April 2,1984.
21. Flaherty, R. E., Letter in response to (Ref 11), desk D-4, Oklahama DOT, Oklahama City, Oklahama, July 20, 1984.
22. Campbell, C., Sneed, L., Tucker, J., "Study to Reduce the Number of Accidents due to Flying Objects from Rotary Mowers," Arkansas State Highway and Transportation Department, October, 1979.
23. Dority, J. E., Letter in response to (Ref 11), Maine DOT, Augusta, Maine, August 31,1984.
24. Buhr, William, Gan, Seng Hark, and Souder, Dalton V., "Design, Development, and Fabrication of a Mower and Its Equipment for The Reduction of Mower-Thrown-Object Accidents," Mechanical Engineering Design Project Report, Department of Mechanical Engineering, The University of Texas at Austin, Spring, 1986.
25. Williams, David A., Allen, Kerry N., and Rinkevich, Timothy R., "Experimental Study and Recommendations for The Reduction of Bat-Wing Mower-Thrown-Object Accidents," Mechanical Engineering Design Project Report, Department of Mechanical Engineering, The University of Texas at Austin, Summer, 1986.
26. Bassignani, Aldo, Lim, Gee Kwang, and Martinez, Hugo, "Development of a Reduced-Mass Mowing Blade for The Reduction of Mower-Thrown Objects," Mechanical Engineering Design Project Report, Department of Mechanical Engineering, The University of Texas at Austin, Summer, 1986.

APPENDIX A

LIST OF PATENTS

APPENDIX A: LIST OF PATENTS

[1] Wood, J. W., "Safety Lawnmower Blade", U.S. patent 3,690,051, Sept. 12, 1972

[2] Hershey, H., "Safety Rotary Blade for a Lawnmower", U.S. patent 3,420,043, Jan. 7, 1969

[3] Dell, J. C., "Safety-Vac Lawnmower Blade", U.S. patent 4,369,618, Jan. 25, 1983

[4] Miskiewicz, L. A., "Safety Shield ", U.S. patent 3,570,225, Mar. 16, 1971.

[5] Siedel, D. P., "Safety Guards for Rotary Lawnmowers", U.S. patent 3,827,220, Aug. 6,1974

[6] Shriver, C. R., "Safety Device for Lawnmowers", U.S. patent 3,871,159 Mar. 18,1975

[7] Dahl, E.S., "Safety Shutter Door Assembly for Rotary Lawnmower Grass Catcher Chute", U.S. patent 3,872,656, Mar. 25,1975

[8] Ramaker, D. D., Keller, R. W., "Safety Shield for Rotary Mower", U.S. patent 3,927,513, Dec. 23, 1975

[9] Owens, B. L., "Lawnmower Safety Control System", U.S. patent 4,221,108, Sept .9, 1980

[10] Kester, B. J., Kester, D. C., Urban, A. L., "Control Assembly for Lawnmower having Electrically Started Engine", U.S. patent 4,466,308, Aug. 21, 1984

[11] Schmitt, L. D., "Method and Apparatus for Controlling Blade Clutch Assembly", U.S. patent 4,432,191, Feb. 21, 1984

[12] Engler, A. R., "Chain Curtain", U.S. patent 3,577,871, May 11, 1971

APPENDIX B

ORGANIZATIONS CONTACTED FOR INFORMATION ON MOWERS

APPENDIX B: ORGANIZATIONS CONTACTED FOR INFORMATION ON MOWERS

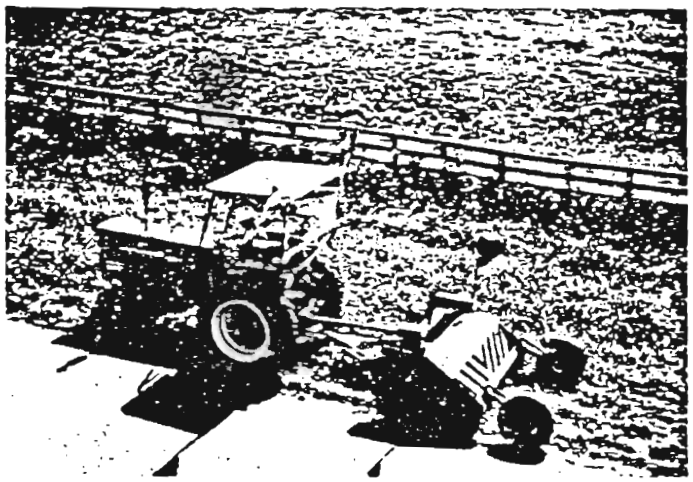
The following organizations were contacted by telephone for information and data on highway mowers. As mentioned in Chapter 2, none of the below-mentioned organizations maintain any information on large rotary mowers used by Highway Departments for their mowing operations.

1. Consumer Product Safety Commission, Washington D.C.,
2. Occupational Safety and Health Administration (OSHA), Washington D.C.,
3. National Safety Council, Chicago, Illinois
4. Outdoor Power Equipment Institute, Washington D.C.,
5. Institute of Agricultural Medicine, University of Iowa, Iowa City, Iowa.

APPENDIX C

HIGHWAY MOWING STANDARDS

MOWING STANDARDS



STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

ADOPTED JANUARY 1978

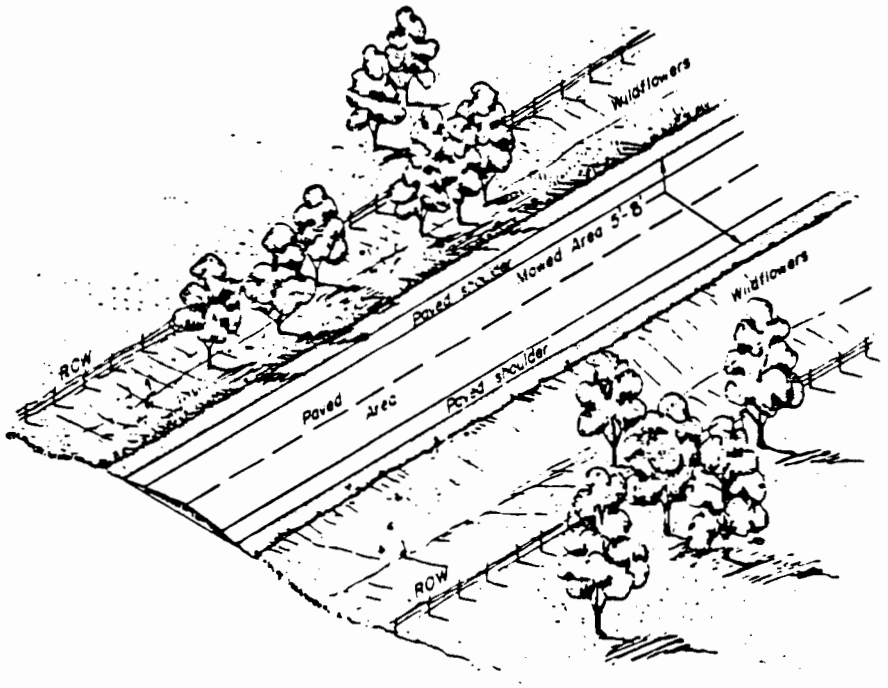
HIGHWAY MOWING STANDARDS

Introduction

The purpose of these mowing standards is to attain uniform maintenance of highway vegetation with appropriate priorities for safety and appearance, with maximum economy in these operations. They prescribe a high standard for mowing which is needed to provide lateral clearance and sight distance. High standards are also prescribed for built-up urban areas. In other areas, full width mowing is reduced in the interest of economy. Higher cutting heights are prescribed to improve the vegetation, increase the capacity of mowing equipment, reduce the hazard of flying objects, and avoid exposing small litter to view. Maximum height standards are given to promote uniformity and reduce excessive mowing. Provisions are made for special purpose mowing, such as; for control of brush and noxious weeds, for reduction of fire hazards, and for erosion control.

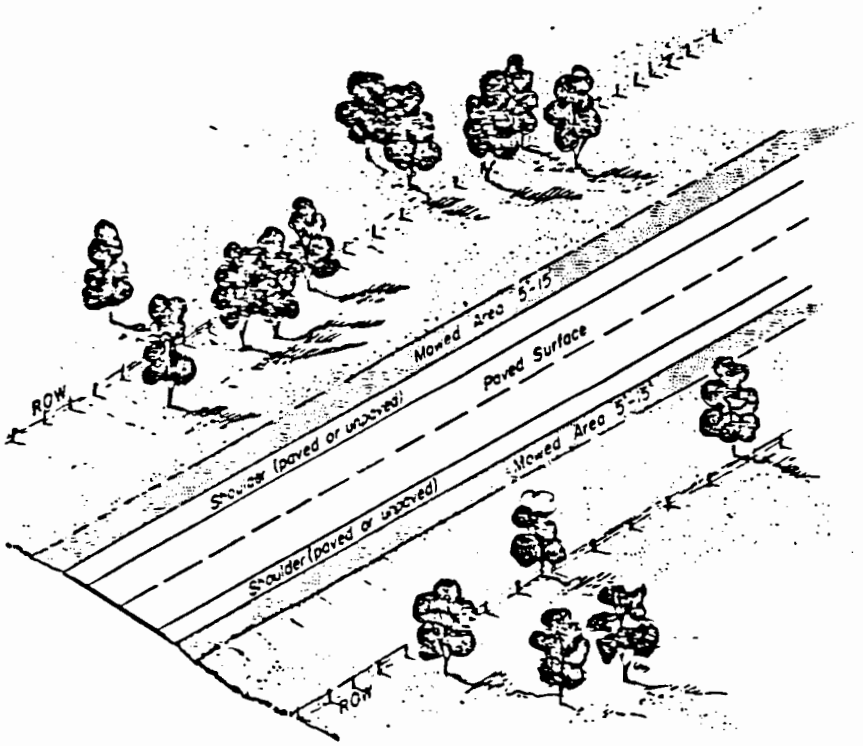
WILD FLOWER PRESERVATION

Full width right-of-way mowing shall be deferred until the early spring flowers have matured seed. In the area where Bluebonnet and Indian Paintbrush grow this will mean about six weeks after the height of their blooming period. Mowing should begin in the Southern portion of the District to allow more time for the flowers to mature seed in the Northern part since spring travels northward at an approximate rate of fifteen miles per day. There may be other varieties of wild flowers that will bloom a bit later that will make a mass display and consideration should be given to permitting their growth when they are not heavily invaded with tall growing weeds and grasses. During this period mowing shall be limited to a single pass of a single rotary or sickle mower adjacent to the pavement to provide for safety.



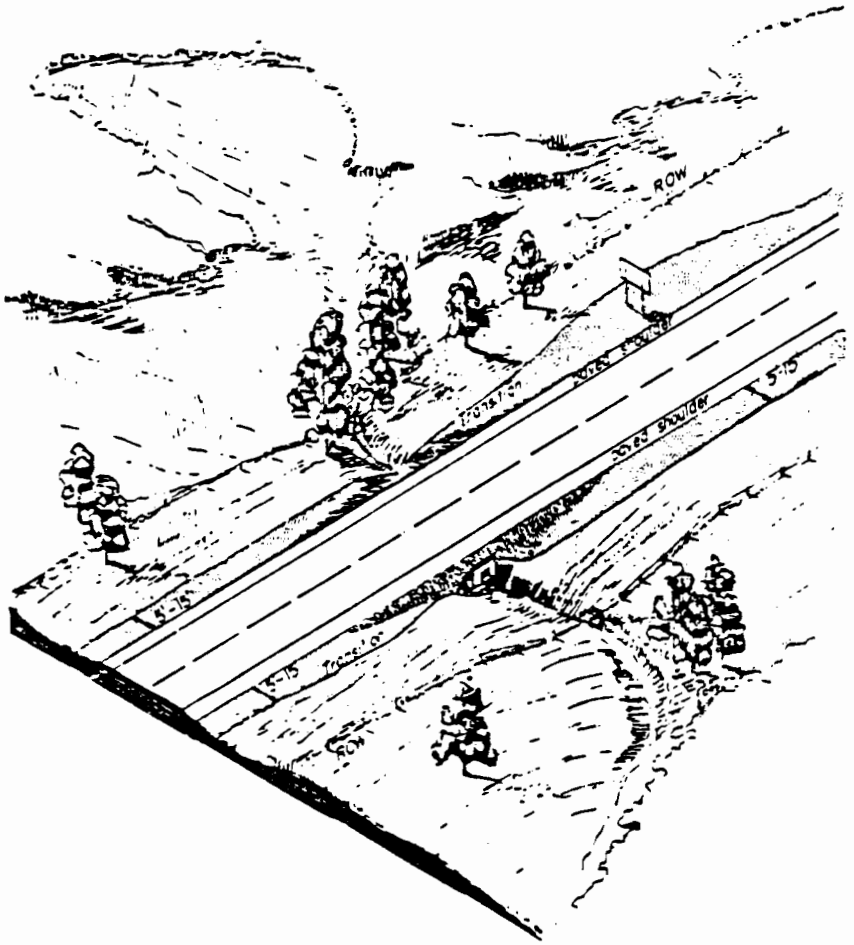
SHOULDER STRIP MOWING

Shoulder Strip Mowing is defined as the area including the shoulder plus a minimum of five (5) feet to a maximum of fifteen (15) feet measured from the crown line. This area shall be mowed as often as necessary for maximum safety and conformance with height standards. On low traffic FM and RM roads a five (5) foot strip will normally be adequate.



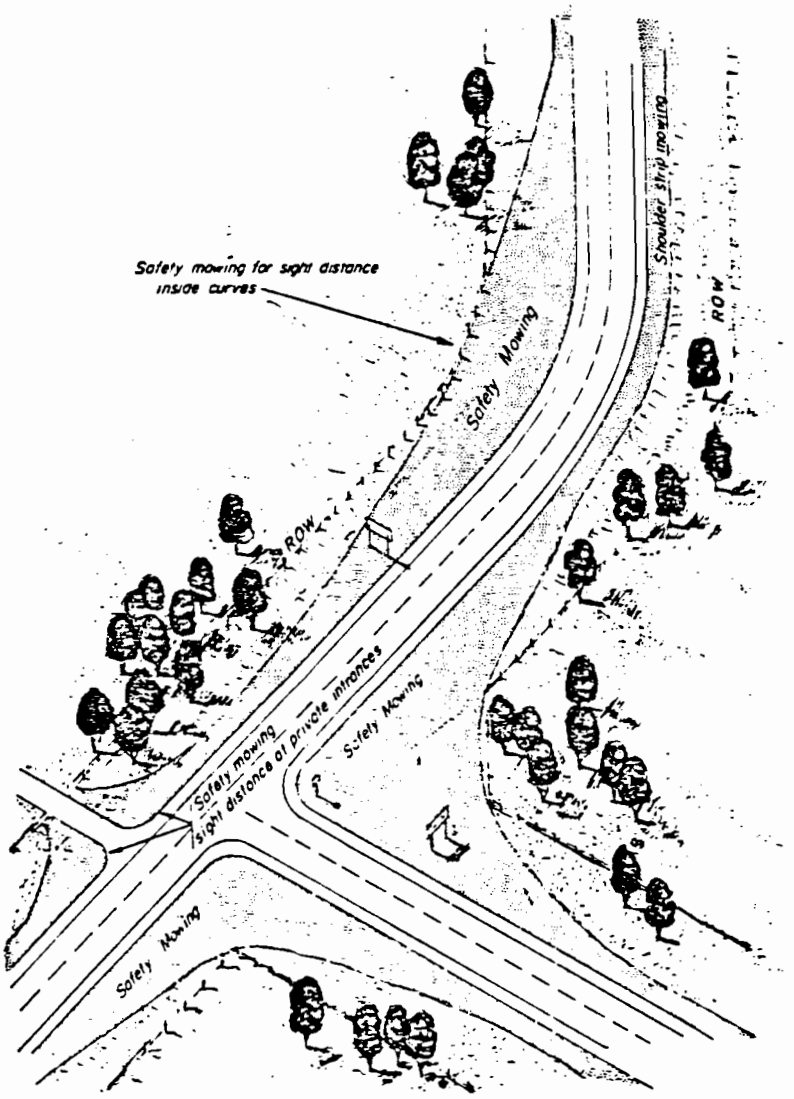
TRANSITION MOWING

Transition or contour mowing should be exercised to provide adequate sight distances for signs or obstructions greater than fifteen (15) feet from edge of shoulder and to avoid abrupt changes in width of mowed area.



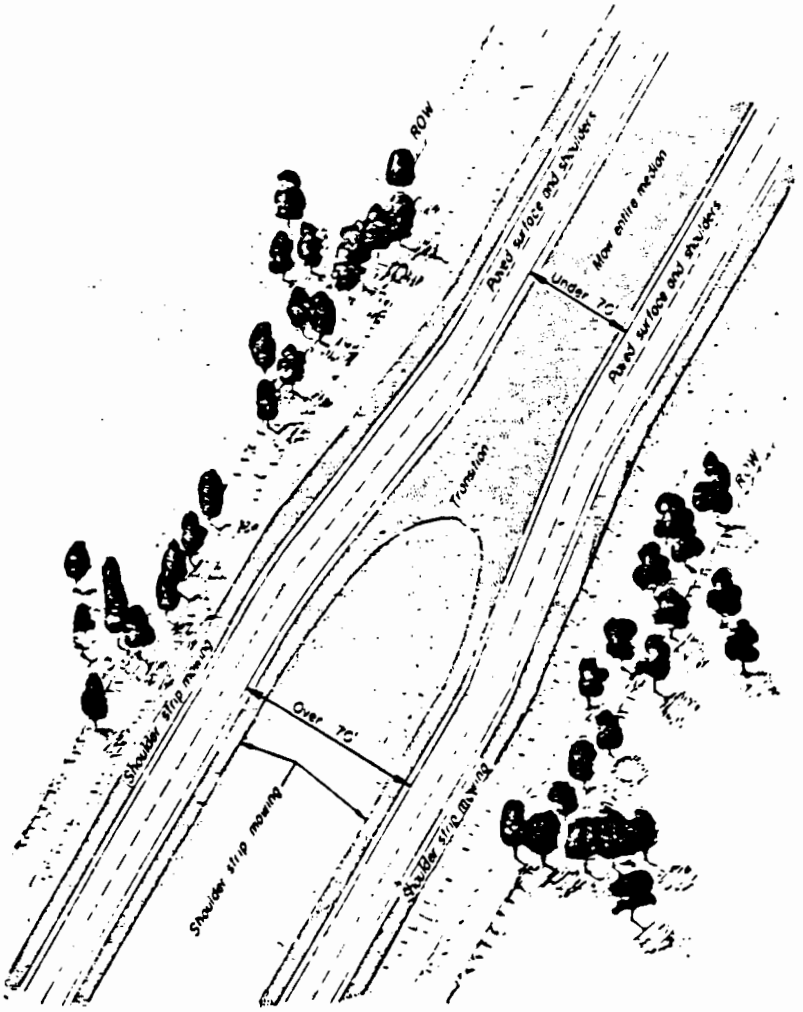
SAFETY MOWING

Mowing shall be performed where needed to maintain sight distance; such as inside curves, off ramps, on ramps, intersections, and private entrances.



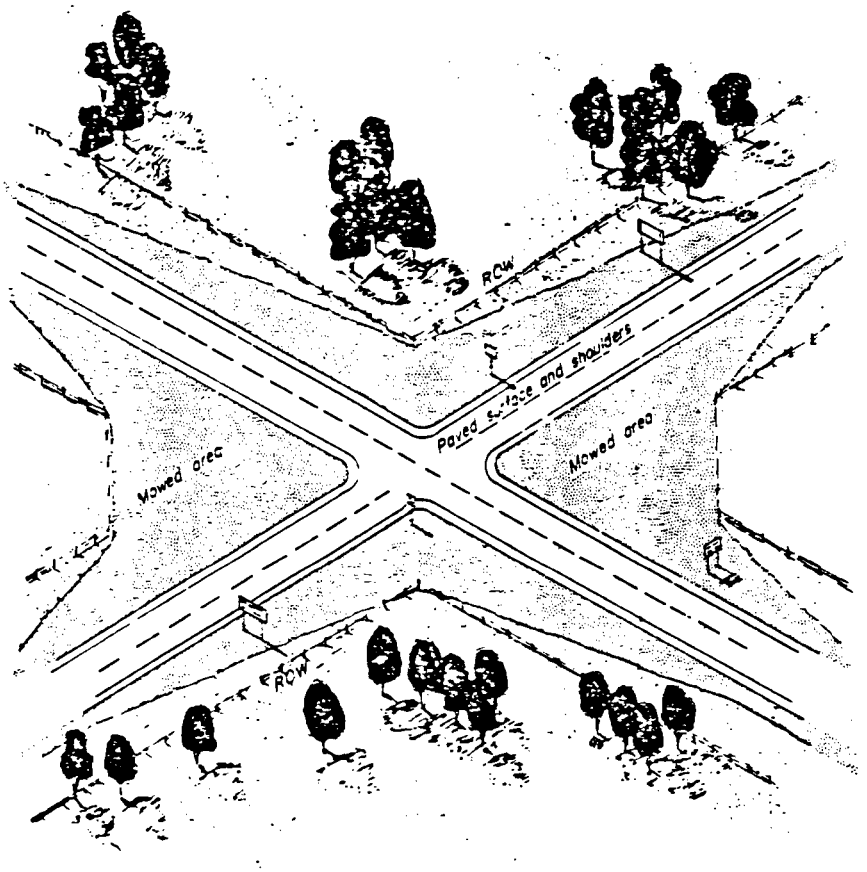
RURAL MEDIANS

The entire area of medians and outer separations which are less than seventy (70) feet in width shall be mowed. On these areas which are over seventy (70) feet in width, only Shoulder Strip Mowing shall be performed. The seventy (70) feet shall be measured from the edge of the traffic lane.



RURAL INTERSECTIONS

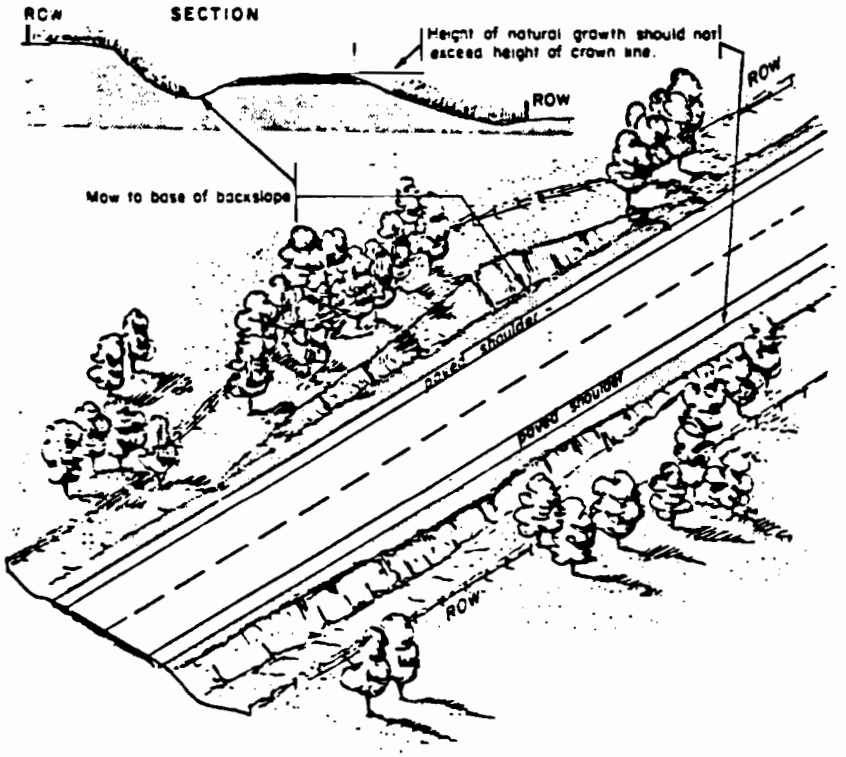
Mowing shall be performed over all areas within the right-of-way necessary to provide adequate sight distance.



OTHER RURAL AREAS

On fill sections, no mowing at all may be necessary, other than Shoulder Strip Mowing; however a strip should be mowed far enough down the slope, to insure that the height of natural growth will not exceed the height of the crownline.

Normally, Shoulder Strip Mowing will be adequate in cut sections; however, mowing should be performed across the ditch to the beginning or base of the backslope at deep cuts where the distance from the crownline to the ditch is not excessive.



CUTTING HEIGHTS

In urban areas the minimum height of cut for turf forming grass, such as Bermuda, St. Augustine, and Centipede, should be three (3) inches. The same kind of grass or a mixture of it with other grasses in the rural area should not be cut lower than five (5) inches. In the Western part of the state where we may have Bermuda or Kentucky Blue Grass under irrigation and Buffalo or Curly Mesquite Grass under natural conditions in urban areas, the height of cut should not be lower than three (3) inches for these turf forming grasses. Where bunch grasses such as Grama, Western Wheat, Green Sprangletop and others are predominant the height of cut should not be lower than seven (7) inches whether it be in an urban or rural area.

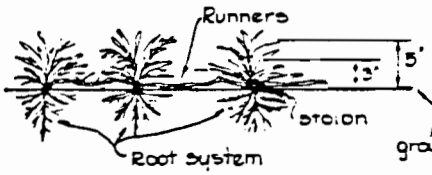
TURF GRASSES

Examples:

- Bermuda
- St. Augustine
- Centipide
- Buffalo
- Curly Mesquite

MINIMUM CUTTING HEIGHT

- Urban — 3"
- Rural — 5"



Turf grasses grow by sending out low growing runners which take root at joints called stolons where new plants have formed. The 3" to 5" cutting height will not interfere with the healthy growth of the plant since the major portion of the leaf surface remains.

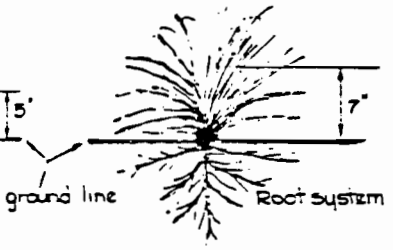
BUNCH GRASSES

Examples:

- Grama
- K.R. Bluestem
- Green Sprangletop
- Western Wheat

MINIMUM CUTTING HEIGHT

- Urban & Rural — 7"



Bunch grasses spread by increasing the size of the leaf area (bunch) above ground. The root system does not spread from its original location. The life of the grass is dependent on the leaf area providing sufficient food to support the root system. For this reason it is essential to have a higher minimum cutting height.

HEIGHT STANDARDS

In areas where mowing is required, other than full width mowing, it shall be performed when the vegetation has reached a height of twelve (12) inches, except on low traffic FM and RM roads where a height of fifteen (15) inches shall govern and in those urban areas where lower heights are necessary to maintain grass cover at desired standard.

URBAN AREAS

Mow all portions of right-of-way as often as is necessary to provide a pleasing appearance consistent with the appearance of abutting property. Urban area shall be defined as developed areas adjacent to and within cities and small towns. Mowing shall be performed in accordance with Municipal Maintenance Agreements where applicable.

FULL WIDTH MOWING

The full width of the right-of-way should normally be mowed only once each year. However, on major highways in areas with heavy rainfall and lush spring growth it may be necessary to mow the entire right-of-way twice each year. The first full width mowing should be performed after the wild flowers season and again in the fall if considered to be necessary. In areas of less than fifteen (15) inch normal annual rainfall, full width mowing will not normally be needed.

HERBICIDES

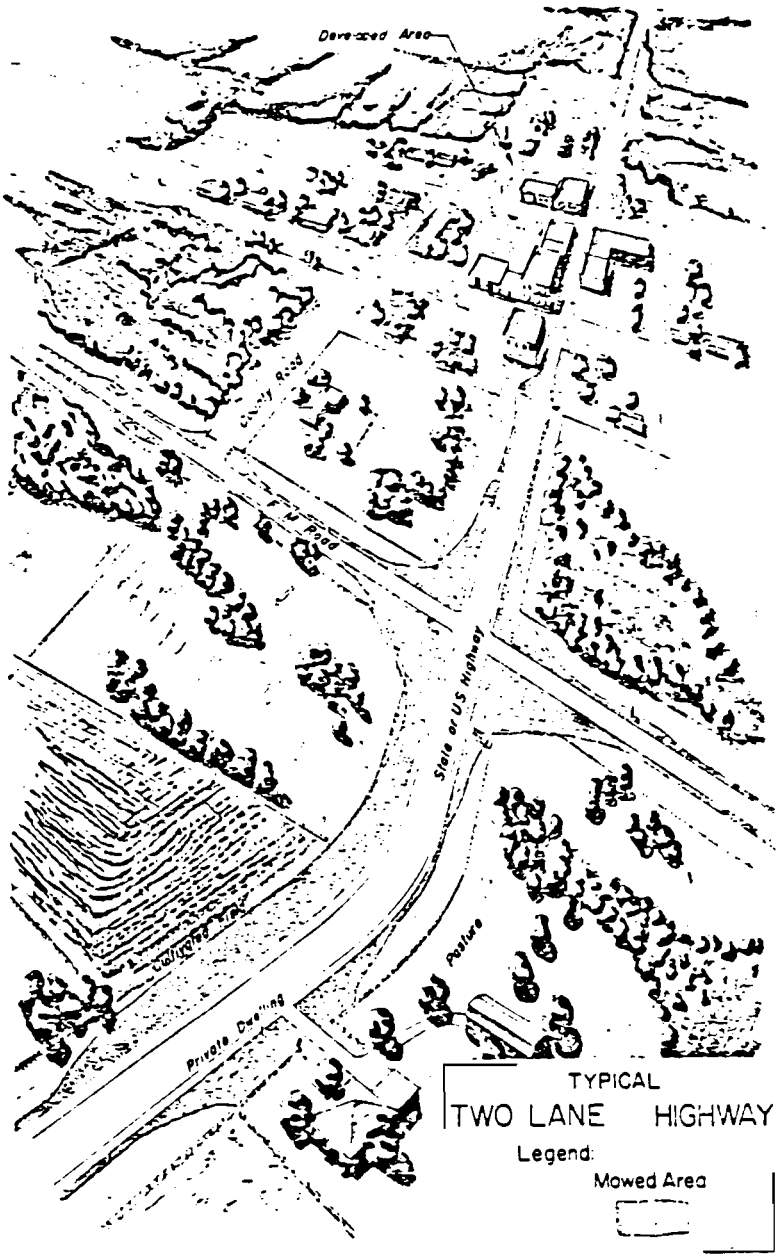
Herbicides should be employed around sign posts, delineators, guardrail and other obstructions to minimize hand mowing.

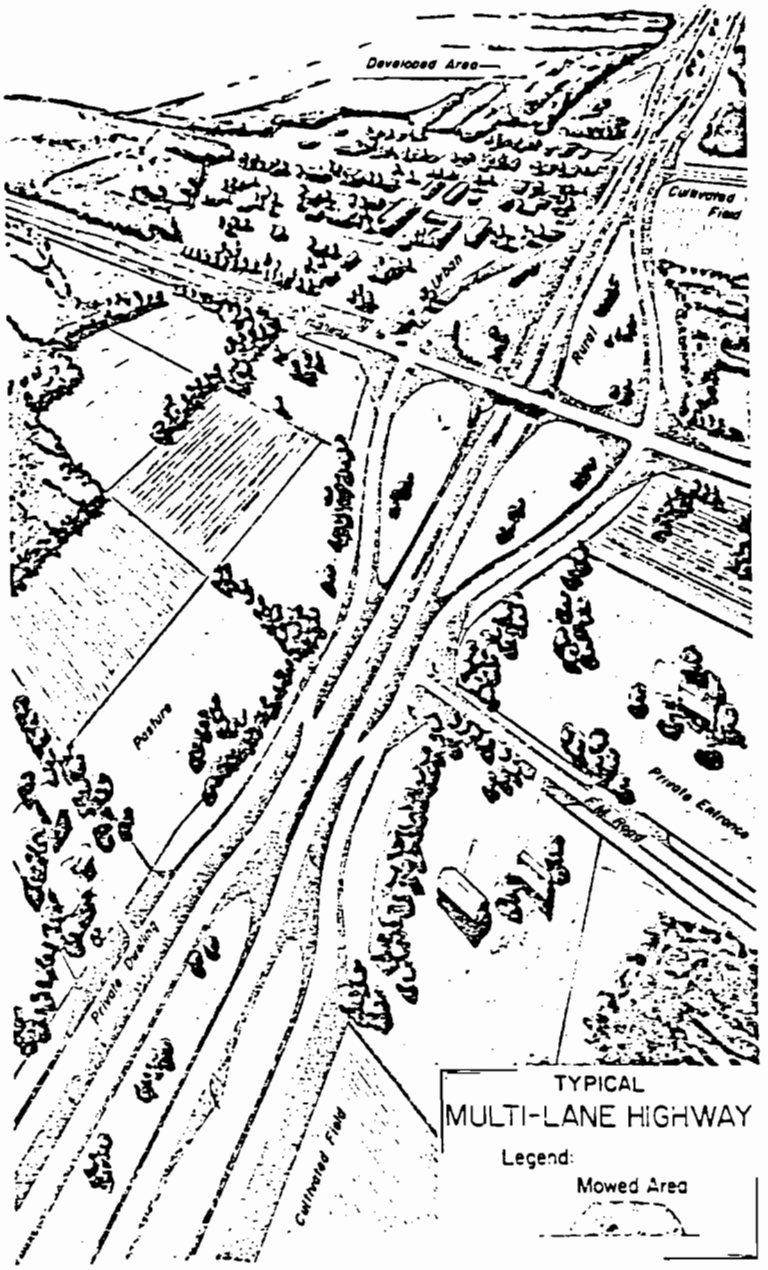
MISCELLANEOUS

The area behind guardrails should be mowed for a sufficient width to prevent encroachment of vegetative growth.

Mowing should be performed as necessary to control brush or noxious weeds, reduce fire hazard and aid in developing sod cover on newly sodded areas or new construction.

In highly developed areas mowing commensurate with the abutting property should be performed.


Deraced Area
State or US Highway
Pasture
Private Driveway
TYPICAL
TWO LANE HIGHWAY
Legend:
Mowed Area


Developed Area
Cultivated Field
Suburban
Rural
Pasture
Private Entrance
Private Dwelling
Cultivated Field
TYPICAL
MULTI-LANE HIGHWAY
Legend:
Mowed Area

MOWING

I. INTRODUCTION

THE PRIMARY GOAL IN MANAGING HIGHWAY VEGETATION IS TO ESTABLISH PERSISTENT VEGETATIVE COVER WITH DENSE CANOPIES OF A DESIRABLE AESTHETIC VALUE, REQUIRING LITTLE OR NO MAINTENANCE AFTER CONSTRUCTION IS COMPLETED. IF THE SLOPE CONSTRUCTION, SOIL PREPARATION, SOIL AMENDMENTS AND SEEDING PRACTICES ARE FULLY IMPLEMENTED THEN A DESIRABLE VEGETATIVE COVER CAN BE ESTABLISHED.

MOWING HIGHWAY CORRIDORS IS AN EXPENSIVE OPERATION REQUIRING SPECIAL AND COSTLY MECHANICAL EQUIPMENT, LABOR, AND FOSSIL FUEL. MOWING HIGHWAYS SUBJECTS PERSONNEL AND TRAVELERS TO POSSIBLE ACCIDENTS. THUS, A MINIMUM MOWING SCHEDULE WILL REDUCE TRAFFIC HAZARDS, LABOR, REPAIRS, EQUIPMENT, AND FUEL COSTS. THE MONEY SAVED ON JUDICIOUS, MINIMUM MOWING FREQUENCIES CAN BE USED FOR MAINTENANCE OF OTHER HIGHWAY FIXTURES.

THE MOWING STANDARDS OF THE TEXAS STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION ADOPTED IN JANUARY 1970 HAS BEEN A VERY WORKABLE AND VIABLE WAY TO MAINTAIN THE VEGETATION ALONG TEXAS HIGHWAYS. HOWEVER, THESE MOWING STANDARDS HAVE USUALLY BEEN INTERPRETED IN THE MOST LIBERAL MANNER AND CONSEQUENTLY MOWING FROM RIGHT-OF-WAY LINE TO RIGHT-OF-WAY LINE HAS BEEN THE COMMON PRACTICE WITH LITTLE REGARD FOR THE VEGETATION OR APPEARANCE OF ADJACENT PROPERTY.

INTERPRETING THE MOWING STANDARDS IN THE FOLLOWING MANNER WILL ALLOW THE MAINTENANCE PERSONNEL TO MOW FOR APPEARANCE, SAFETY, WILDFLOWER PRESERVATION, NOXIOUS WEED CONTROL, AND ALLOW THE RIGHT-OF-WAY TO BECOME COMPATIBLE WITH ADJACENT PROPERTIES.

II. HIGHWAY MOWING STANDARDS

A. WILDFLOWER PRESERVATION

IN AREAS WHERE FULL WIDTH MOWING WILL BE NECESSARY SUCH AS CULTIVATED FARMLANDS, URBAN AREAS, AND TOWNSHIPS, IT SHALL BE DEFERRED UNTIL THE EARLY SPRING FLOWERS HAVE MATURED SEEDS. IN THE BLUEBONNET AND INDIAN PAINTBRUSH AREAS THIS WILL BE APPROXIMATELY FOUR (4) WEEKS AFTER THE BLOOMS FADE. THERE MAY BE OTHER WILDFLOWERS IN THE AREA THAT WILL BLOOM LATER AND SHALL NOT BE MOWED. DURING THIS PERIOD OF WILDFLOWER PRESERVATION, MOWING SHALL BE LIMITED TO A SINGLE PASS OF A SINGLE ROTARY OR SICKLE MOWER ADJACENT TO THE

PAVEMENT FOR SAFETY. GOOD WILDFLOWER AREAS SHALL HAVE ONE FULL WIDTH MOWING IN THE FALL.

B. SHOULDER STRIP MOWING

SHOULDER STRIP MOWING IS DEFINED AS THE AREA INCLUDING THE SHOULDER PLUS A MINIMUM OF FIVE (5) FEET TO A MAXIMUM OF FIFTEEN (15) FEET MEASURED FROM THE EDGE OF THE PAVEMENT. THIS AREA SHALL BE MOWED AS OFTEN AS NECESSARY FOR MAXIMUM SAFETY AND CONFORMANCE WITH HEIGHT STANDARDS. ON LOW TRAFFIC FM AND RM ROADS A FIVE (5) FOOT STRIP WILL NORMALLY BE ADEQUATE.

C. TRANSITION MOWING

TRANSITION OR CONTOUR MOWING SHALL BE PERFORMED TO PROVIDE ADEQUATE SIGHT DISTANCE FOR SIGNS OR FIXTURES GREATER THAN FIFTEEN (15) FEET FROM EDGE OF THE SHOULDER. ABRUPT CHANGES IN THE MOWING PATTERNS SHOULD BE AVOIDED TO LESSEN VISUAL IMPACT.

D. SAFETY MOWING

SAFETY MOWING SHALL BE PERFORMED WHEN AND WHERE NECESSARY TO MAINTAIN SIGHT DISTANCES; SUCH AS INSIDE CURVES, OFF RAMPS, ON RAMPS, INTERSECTIONS, AND PRIVATE ENTRANCES.

E. RURAL MEDIANS

THE ENTIRE AREA OF MEDIANS AND OUTER SEPARATIONS WHICH ARE LESS THAN SEVENTY (70) FEET IN WIDTH SHALL BE MOWED UNLESS THE GRADE IS TOO STEEP OR THE AREA IS COVERED WITH DESIRABLE TREES, SHRUBS, ETC. ON MEDIANS AND OUTER SEPARATIONS WHICH ARE MORE THAN SEVENTY (70) FEET IN WIDTH; ONLY TRANSITION AND SHOULDER STRIP MOWING SHALL BE PERFORMED. THIS APPLIES TO ALL DIVIDED HIGHWAYS INCLUDING STATE, U. S. AND INTERSTATE HIGHWAYS. THE SEVENTY (70) FEET SHALL BE MEASURED FROM THE EDGE OF THE TRAFFIC LANE.

F. RURAL INTERSECTIONS

MOWING SHALL BE PERFORMED OVER RURAL INTERSECTION OR INTERCHANGE AREAS AS NECESSARY TO PROVIDE ADEQUATE SIGHT DISTANCES.

G. OTHER RURAL AREAS

ON FILL SECTIONS MOWING WILL NOT BE NECESSARY, OTHER THAN SHOULDER STRIP MOWING.

SHOULDER STRIP MOWING WILL BE ADEQUATE IN CUT SECTIONS; HOWEVER, MOWING SHALL BE PERFORMED ACROSS THE DITCH LINE TO THE BEGINNING OR BASE OF THE BACKSLOPE AT DEEP CUTS WHERE THE DISTANCE FROM THE EDGE OF THE PAVEMENT TO THE DITCH BOTTOM IS NOT EXCESSIVE.

H. CUTTING HEIGHTS

IN URBAN AREAS THE MINIMUM HEIGHT OF CUT FOR TURF FORMING GRASSES, SUCH AS BERMUDA, ST. AUGUSTINE, AND CENTIPEDE SHALL BE FOUR (4) INCHES. THESE SAME GRASSES OR A MIXTURE OF THESE OTHER GRASSES IN RURAL AREAS SHALL BE CUT TO A HEIGHT OF SIX (6) INCHES. IN URBAN AREAS OF THE WESTERN PART OF THE STATE, TURF FORMING GRASSES SUCH AS BERMUDA OR KENTUCKY BLUE GRASS UNDER IRRIGATION CONDITIONS AND BUFFALOGRASS OR CURLY MESQUITE GRASS UNDER NATURAL CONDITIONS SHALL BE CUT TO A HEIGHT OF FOUR (4) INCHES. BUNCH GRASSES SUCH AS GRAMA, WESTERN WHEAT, GREEN SPRANGLETOP, AND K.R. BLUESTEM SHALL BE CUT TO A HEIGHT OF SEVEN (7) INCHES WHETHER IN URBAN OR RURAL AREAS. WHERE K.R. BLUESTEM IS THE PREDOMINANT GRASS IT SHALL NOT BE MOWED IN THE FALL UNTIL AFTER THE FIRST KILLING FROST.

I. HEIGHT STANDARDS

IN AREAS WHERE MOWING IS REQUIRED, OTHER THAN FULL WIDTH MOWING, IT SHALL BE PERFORMED WHEN THE VEGETATION HAS REACHED A HEIGHT OF TWELVE (12) INCHES EXCEPT ON LOW TRAFFIC FM AND RM ROADS WHERE A HEIGHT OF FIFTEEN (15) INCHES SHALL GOVERN.

J. URBAN AREAS

MOW ALL PORTIONS OF THE RIGHT-OF-WAY AS OFTEN AS NECESSARY TO PROVIDE A PLEASING APPEARANCE CONSISTENT WITH THE APPEARANCE OF ADJACENT PROPERTY. URBAN AREAS SHALL BE DEFINED AS DEVELOPED AREAS ADJACENT TO AND WITHIN CITIES AND TOWNS. MOWING SHALL BE PERFORMED IN ACCORDANCE WITH MUNICIPAL MAINTENANCE AGREEMENTS WHERE APPLICABLE.

K. FULL WIDTH MOWING

FULL WIDTH MOWING WILL ONLY BE REQUIRED IN URBAN AREAS, CULTIVATED FARM AREAS,AND PROMINENT WILDFLOWER AREAS. IN THE FARM AREAS, THE RIGHT-OF-WAY SHALL BE FULL WIDTH MOWED AFTER THE WILDFLOWERS HAVE MATURED SEEDS AND AGAIN IN THE FALL OR AS NEEDED TO CONTROL NOXIOUS WEEDS. IN OTHER WILDFLOWER AREAS THE FULL WIDTH MOWING SHALL BE PERFORMED ONE TIME IN THE FALL. IT IS DESIRABLE IN URBAN AREAS WHICH HAVE GOOD WILDFLOWERS, TO DELAY FULL WIDTH MOWING UNTIL AFTER THE SEEDS ARE MATURE AND THEN MOW AS NECESSARY. THE AREAS RECEIVING ONLY STRIP MOWING AS MENTIONED IN PREVIOUS PARAGRAPHS SHALL BE ALLOWED TO REVEGETATE WITH VEGETATION NATIVE TO THE AREA. AS THIS REVEGETATION DEVELOPS, THE RIGHT-OF-WAY WILL BLEND WITH THE ADJACENT PROPERTIES.

L. MISCELLANEOUS

MOWING SHALL BE PERFORMED AS NECESSARY FOR SAFETY IN WILDLIFE CROSSINGS, TO CONTROL NOXIOUS WEEDS, AND AID IN DEVELOPING SOD COVER ON NEWLY SODDED AREAS OR NEW CONSTRUCTION.

RIGHT-OF-WAY ADJACENT TO RAILROAD RIGHT-OF-WAY SHALL ONLY BE SHOULDER STRIP MOWED.

REST AREAS AND PICNIC AREAS SHALL BE MOWED IN A MANNER TO INSURE SAFETY FOR THE TRAVELING PUBLIC. HOWEVER, MOWING PATTERNS SHALL BE UTILIZED TO PRESERVE SPRING WILDFLOWERS FOR THE ENJOYMENT OF THE TRAVELING PUBLIC.

M. HERBICIDES

HERBICIDES SHALL BE UTILIZED AROUND SIGN POSTS, DELINEATORS, GUARDRAILS, AND OTHER HIGHWAY FIXTURES TO MINIMIZE HAND MOWING. CHEMICAL MOWING MAY ALSO BE USED TO REDUCE MECHANICAL MOWING. DETAILS ON HERBICIDES WILL BE COVERED FULLY IN THE VEGETATION MANAGEMENT MANUAL ON HERBICIDES.

III. MAINTENANCE SECTION EVALUATION

A. EVALUATION

EACH MAINTENANCE SECTION WILL NEED TO BE VISUALLY EVALUATED IN ORDER TO DETERMINE THE AMOUNT OF ACREAGE TO BE MOWED AS GOVERNED BY THE ABOVE MOWING STANDARDS. AREAS NOT TO BE MOWED WILL NEED TO BE DETERMINED AND MAINTAINED BY NOT ALLOWING THE MOWERS IN THESE AREAS.

B. CONTRACT

APPENDIX D

SDHPT MOWER PURCHASE SPECIFICATIONS

APPENDIX D: SDHPT MOWER PURCHASE SPECIFICATIONS

STATE OF TEXAS
STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION
EQUIPMENT AND PROCUREMENT DIVISION

SPECIFICATION NO.
SDHPT-020-15-01
REVISED: AUGUST, 1985

Does Unit Meet The Purchase Specs?

84 INCH, LIFT TYPE,
PTO DRIVEN, FLAIL MOWER

PART I
GENERAL CLAUSES AND CONDITIONS

YES/NO

1.0 The equipment furnished under these specifications shall be the latest improved model in current production, as offered to commercial trade, and shall be of quality workmanship and material. The bidder represents that all equipment offered under these specifications shall be new. USED, SHOPWORN, DEMONSTRATOR, PROTOTYPE, OR DISCONTINUED MODELS ARE NOT ACCEPTABLE. / / /

2.0 Bidders should submit with their bid, or have on file with the State Department of Highways and Public Transportation, Austin, Texas, the latest printed literature and detailed specifications on equipment the bidder proposes to furnish. This literature is for informational purposes only.

3.0 The unit(s) shall be completely assembled, adjusted, and all equipment including standard and supplemental equipment be installed and the unit made ready for continuous operation. /

4.0 All parts not specifically mentioned which are necessary for the unit to be complete and ready for operation or which are normally furnished as standard equipment shall be furnished by the successful bidder. All parts shall conform in strength, quality and workmanship to the accepted standards of the industry. /

5.0 The unit(s) provided shall meet or exceed all Federal and State of Texas safety, health, lighting and noise regulations and standards in effect and applicable to equipment furnished at the time of manufacture.

6.0 Any variation from these specifications must be indicated on the Bid or on a separate attachment to the Bid. This sheet shall be labeled as such.

PART II
SPECIFICATIONS

1.0 This Specification describes a lift type, PTO driven flail mower to be used in highway right-of-way mowing operations. The mower shall be designed and constructed in a sturdy manner to be able to consistently withstand the severe stresses encountered in continuous highway right-of-way mowing operations. The mower must meet the structural and safety requirements recommended in Safety Criteria for Industrial Flail Mowers--SAE J1001 or latest revision thereto. The mower shall provide a cutting width of at least eighty-four inches (84") and be equipped with a hitch assembly suitable for use with the tractor identified on the Invitation to Bid. Units furnished to these specifications must meet or exceed all requirements herein. / / / /

2.0 EXAMPLES: Ford Model 917, 88 inch
Mott Model 88

NOTICE TO BIDDERS: Any example shown is listed to show type and class of equipment desired. Bidders are cautioned to read the specifications carefully, as there may be special requirements not commonly offered by the equipment manufacturer. Do not assume your standard equipment meets all detailed specifications merely because it is listed as an example. Bidders are cautioned that units delivered to the F.O.B. points which do not meet specifications in every aspect will not be accepted.

3.0 HOOD END PLATES AND REAR ROLLER: The cutter shaft shall be covered by a steel hood measuring at least 0.0897 inch thick (13 gauge) and be supported by heavy duty end plates. The hood and end plates shall be sufficiently reinforced to withstand the impact of objects thrown during continuous highway right-of-way mowing operations. A full width roller measuring at least five and one-half inches (5-1/2") in diameter shall be mounted below and behind the cutter shaft. / / / / / /

3.1 The rear roller shall be covered by the hood or a heavy gauge steel deflector. A deflector curtain extending the full width of the rear roller shall also be provided. / /

3.2 When mowing, the hood, end plates, rear roller, deflector curtain, related shields, and guards, shall provide coverage of the cutter shaft and cutting knives so that the discharge of the mower is channeled or deflected downward. The discharge shall be beneath or immediately behind the mower. / /
NOTE: The members providing coverage of the cutter shaft and cutting knives shall also serve as safety shields or protective guards to prevent personnel from becoming entangled by the mower. /

YES/NO

3.3 The end plates shall have bolt-on, wear-resistant and replaceable steel skid shoes, or else the mower shall have two (2) rear mounted adjustable caster wheels to minimize unintentional scalping. If caster wheels are provided, they shall be 360° continuous rotation type with solid type tires. Skid shoes and caster wheels shall be designed, constructed, and installed on the mower so that they will not bend, break, or fall off during mower operation. ___/___

3.4 The rear roller shall be suspended on anti-friction bearings. The bearings shall be sealed or equipped with lubrication fittings. ___/___

4.0 CUTTER SHAFT AND CUTTING KNIVES: The unit shall have a dynamically balanced, vibration-free cutter shaft suspended on anti-friction bearings. The bearings shall be sealed or equipped with lubrication fittings. Each bearing shall be protected from snagging on obstructions by the final drive housing and/or by a bumper guard. ___/___

4.1 The cutting knives shall be fine cut general purpose type, individually replaceable, free swinging and offset to give an even cut the full length of the rotor. The tempered steel cutting knives shall be of sufficient strength so as not to bend, break, crack or chip when contacting objects normally encountered in highway right-of-way mowing operations. ___/___

4.2 The cutting height range offered by the mower shall be adjustable such that at least four (4) different cutting heights are provided throughout the range of two inches (2") to at least five inches (5") above the ground. One (1) of the required cutting heights shall allow for cutting approximately three inches (3") above the ground, another of the required cutting heights shall allow for cutting at least five inches (5") but not more than seven inches (7") above the ground (it is preferred but not required that the seven inch (7") cutting height be provided). ___/___

5.0 DRIVE: Power for the mower drive train shall be furnished by a 540 RPM tractor mounted 1-3/8 inch splined power take-off shaft.

5.1 The drive train shall consist of a universal jointed shielded drive shaft from the tractor PTO to a gear box mounted on top of the mower. ___/___

5.2 The gear box shall have heat treated steel gears which are machine cut and lubricated by oil or grease. The gear box shall be sealed and the gears shall be mounted on anti-friction bearings. ___/___

5.3 A shielded drive shaft shall power the final drive from the gear box. ___/___

5.4 The final drive shall be by belt and pulley system. ___/___

5.5 The final drive shall have a steel safety shield to prevent personal injury. The shield shall also allow for easy access to the final drive for maintenance purposes. ___/___

5.6 The final drive safety shield shall measure at least 1/8 inch thick or else, the safety shield shall have a bumper guard to prevent the safety shield and final drive from snagging on obstructions. ___/___

6.0 SAFETY PLAQUE(S) OR DECAL(S): Safety plaque(s) or decal(s) shall be furnished and shall be affixed at any hazardous area. The plaque(s) or decal(s) shall include necessary warnings and precautions. Permanent plaques are preferred to decals. ___/___

7.0 PAINTING: The unit shall be painted Federal Yellow No. 13538 of Federal Standard 595a except for glass, rubber and those metallic accessories or fixtures constructed of rust-resistant or plated material not normally painted. Lead-free paint will be accepted if it matches the color of Federal Yellow No. 13538. Examples of paints meeting this requirement are: ___/___

Du Pont No. BN552
PPG Industries No. 81958
Sherwin Williams No. 6351

8.0 MANUALS: Manual or manuals containing illustrated parts list, operating and service instructions for the unit shall be delivered with each unit. The manual(s) shall be as detailed as possible outlining all necessary service and operating instructions for the unit delivered. Necessary warnings and safety precautions shall be included. ___/___

9.0 WARRANTY: The unit of equipment shall be warranted against defects in material and workmanship for a period of not less than twelve (12) months from the date that the unit is placed into service. If the manufacturer's standard warranty exceeds twelve (12) months, then the standard warranty period shall be in effect. Successful bidder shall furnish manufacturer's warranty to the receiving district at time of delivery. ___/___

SPECIFICATION NO.
SDHPT-020-15-01
REVISED: AUGUST, 1985

YES/NO

NOTE: Provisions shall be made by the successful bidder to provide a delayed warranty start date for each unit furnished to this specification. Warranty start date shall be effective the day the completed unit is placed into service. Instructions are to be included with each unit delivered, advising State personnel of the procedures to be followed for obtaining the delayed warranty start date. /

10.0 DATA SHEET: The attached Data Sheet should be completed and submitted in duplicate for informational purposes only.

PART III
OPTIONAL EQUIPMENT

Optional equipment must be identified on the Invitation to Bid to be required.

OPTION NO. 1

1.0 CASTER WHEELS: The mower shall have two (2) rear mounted adjustable caster wheels. Caster wheels shall be 360° continuous rotation type with solid type tires. Caster wheels shall be designed, constructed, and installed on the mower so that they will not bend, break, or fall off during mower operation. / / / /

OPTION NO. 2

2.0 COARSE CUT UNIT: In lieu of the unit being equipped as described in Paragraphs 4.1 and 4.2, Part II of this Specification, the unit shall be equipped as follows:

2.1 Mower shall be equipped with caster wheels, Option No. 1 above. /

2.2 The cutting knives shall be coarse cut general purpose type, reversible, individually replaceable, free swinging and offset to give an even cut the full length of the rotor. The tempered steel cutting knives shall be of sufficient strength so as not to bend, break, crack or chip when contacting objects normally encountered in highway right-of-way mowing operations. / / /
NOTE: These knives must be suitable for use in extremely heavy grass and stalks in trash conditions.

2.3 The cutting height range offered by the mower shall be adjustable such that at least four (4) different cutting heights are provided throughout the range of two inches (2") to at least seven inches (7") above the ground. One (1) of the required cutting heights shall allow for cutting three inches (3") above the ground, another of the required cutting heights shall allow for cutting seven inches (7") above the ground. / / / /

EXAMPLE: Mott Model 88, or equal.

STATE OF TEXAS
STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION
EQUIPMENT AND PROCUREMENT DIVISION

SPECIFICATION NO.
SDHPT-020-16-02
REVISED: MARCH, 1982

PART I
84 INCH ROTARY MOWER
HEAVY DUTY
GENERAL CLAUSES AND CONDITIONS

1.0 The equipment furnished under these specifications shall be the latest improved model in current production, as offered to commercial trade, and shall be of quality workmanship and material. The bidder represents that all equipment offered under these specifications shall be new. USED, SHOPWORN, DEMONSTRATOR, PROTOTYPE, OR DISCONTINUED MODELS ARE NOT ACCEPTABLE.

2.0 Bidders must submit with their bid, or have on file with the State Department of Highways and Public Transportation, Austin, Texas, the latest printed literature and detailed specifications on equipment the bidder proposes to furnish. This literature shall include an engine chart, if applicable, corrected to standard conditions of air temperature and pressure showing horsepower and other characteristics.

3.0 The unit(s) shall be completely assembled, adjusted, and all equipment including standard and supplemental equipment be installed and the unit made ready for continuous operation.

4.0 All parts not specifically mentioned which are necessary for the unit to be complete and ready for operation or which are normally furnished as standard equipment shall be furnished by the successful bidder. All parts shall conform in strength, quality and workmanship to the accepted standards of the industry.

5.0 The unit(s) provided shall meet or exceed all Federal and State of Texas safety, health, lighting and noise regulations and standards in effect and applicable to equipment furnished at the time of manufacture.

6.0 Any variation from these specifications must be indicated on the Bid or on a separate attachment to the Bid. This sheet shall be labeled as such.

STATE OF TEXAS
STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION
EQUIPMENT AND PROCUREMENT DIVISION

SPECIFICATION NO.
SDHPT-020-16-01
REVISED: SEPTEMBER, 1981

PART I
60 AND 72 INCH LIFT TYPE ROTARY MOWERS
GENERAL CLAUSES AND CONDITIONS

1.0 The equipment furnished under these specifications shall be the latest improved model in current production, as offered to commercial trade, and shall be of quality workmanship and material. The bidder represents that all equipment offered under these specifications shall be new. USED, SHOPWORN, DEMONSTRATOR, PROTOTYPE, OR DISCONTINUED MODELS ARE NOT ACCEPTABLE.

2.0 Bidders must submit with their bid, or have on file with the State Department of Highways and Public Transportation, Austin, Texas, the latest printed literature and detailed specifications on equipment the bidder proposes to furnish. This literature shall include an engine chart, if applicable, corrected to standard conditions of air temperature and pressure showing horsepower and other characteristics.

3.0 The unit(s) shall be completely assembled, adjusted, and all equipment including standard and supplemental equipment be installed and the unit made ready for continuous operation.

4.0 All parts not specifically mentioned which are necessary for the unit to be complete and ready for operation or which are normally furnished as standard equipment shall be furnished by the successful bidder. All parts shall conform in strength, quality and workmanship to the accepted standards of the industry.

5.0 The unit(s) provided shall meet or exceed all Federal and State of Texas safety, health, lighting and noise regulations and standards in effect and applicable to equipment furnished at the time of manufacture.

6.0 Any variation from these specifications must be indicated on the Bid or on a separate attachment to the Bid. This sheet shall be labeled as such.

SPECIFICATION NO.
SDHPT-020-16-01
REVISED: SEPTEMBER, 1981

PART II
SPECIFICATIONS FOR
60 AND 72 INCH LIFT TYPE ROTARY MOWERS

1.0 It is the purpose and intent of this Specification to describe a Lift Type Rotary Mower having a minimum cutting width of 60 or 72 inches. The width required shall be identified on the Invitation to Bid. The mowers furnished under this Specification shall be of heavy duty design capable of withstanding continuous highway right-of-way mowing. The mower shall be equipped with three (3) point hookup.

2.0 EXAMPLES:

60 INCH	72 INCH
Caldwell 60 Brush Beaver	Caldwell 72 Brush Beaver
Ford 941	Ford 943
John Deere 509	John Deere 609
Modern Highway Special 5 Ft.	Modern Highway Special 6 Ft.
Servis 60 Cyclone	Servis 72 Cyclone
Terrain King TK60	Terrain King TK72
Woods MR105P	Woods MR106P

NOTICE TO BIDDERS: Any example shown is listed to show type and class of equipment desired. Bidders are cautioned to read the specifications carefully, as there may be special requirements not commonly offered by the equipment manufacturer. Do not assume your standard equipment meets all detailed specifications merely because it is listed as an example. Bidders are cautioned that units delivered to the F.O.B. points which do not meet specifications in every aspect will not be accepted.

3.0 FRAME AND CAGE: The mower shall have an electrically welded frame covered on the sides and top with a minimum 11 gauge (0.1196 inch) steel plate.

3.1 The cage shall be a minimum seven (7) inches deep.

3.2 The front opening shall be enclosed with a single row chain guard and the rear opening shall be enclosed with a double row chain guard.

3.3 The length of each strand of chains should be such that with the mower set to cut at a height of five (5) inches the bottom link will touch the ground.

3.4 Chain guard rows shall be placed in such a position that under maximum deflection conditions, the chain will not contact the cutting blades.

3.5 A steel cable shall be laced horizontally through the next to the bottom link of each strand. The cable shall be fastened with a cable clamp to the last strand at each end of the opening. In the rear the cable shall be installed in the outside row only.

3.6 The sides of the mower shall be equipped with heavy duty steel skid plates.

4.0 SUPPORT WHEEL: The mower shall be equipped with a 360 degree swivel caster trailing wheel with anti-friction bearings.

5.0 DRIVE: Power for the mower drive train shall be furnished by a 540 RPM tractor mounted power take-off.

5.1 The drive train shall consist of universal jointed shielded drive shaft from the tractor PTO to a gear box mounted on top of the mower cage.

5.2 The gear box shall have an enclosed transmission of heat treated steel gears lubricated by oil or grease.

5.3 The gear box shall be protected by a slip clutch.

6.0 BLADES: The mower blades shall be heat treated steel and shall be the free swinging type which fold back when hitting an obstruction.

6.1 The blade holder may be dish or hub type.

7.0 CUTTING HEIGHT: The cutting height shall be adjustable from a minimum of not more than three (3) inches to a maximum of not less than eight (8) inches.

8.0 WEIGHT: The weight of the 60 inch mower shall be a minimum 725 pounds and the 72 inch mower shall be a minimum 890 pounds. Addition of weights to meet this requirement is not acceptable.

9.0 PAINTING: The unit shall be painted Federal Yellow No. 13538 of Federal Standard 595a except for glass, rubber and those metallic accessories or fixtures constructed of rust-resistant or plated material not normally painted. Lead free paint will be accepted if it matches the color of Federal Yellow No. 13538.

10.0 MANUALS: Manual or manuals containing illustrated parts list, operating and service instructions for the unit and engine (if applicable) shall be delivered with the unit. The manual(s) shall be as detailed as possible outlining all necessary service and operating instructions for the unit delivered. Necessary warnings and safety precautions shall be included.

11.0 WARRANTY: The unit of equipment shall be warranted against defects in material and workmanship for a period of not less than twelve (12) months. if the manufacturer's standard warranty exceeds twelve (12) months, then the standard warranty period shall be in effect. Successful bidder shall furnish manufacturer's warranty to the receiving District at time of delivery.

12.0 DATA SHEET: The attached Data Sheet must be completed and submitted in duplicate as a part of the bid. Failure to comply may be grounds for rejecting the bid. Information contained therein shall become a part of the contract, if awarded.

PART III
60 AND 72 INCH LIFT TYPE
ROTARY MOWERS
OPTIONAL EQUIPMENT

Optional equipment must be identified on the Invitation to Bid to be requested.

OPTION NO. 1 - Shear Pin: The mower gear box shall be protected by means of a shear pin in lieu of the slip clutch as identified in Paragraph 5.3, Page 3-4.

SPECIFICATION NO.
SDHPT-020-16-02
REVISED: MARCH, 1982

PART II
SPECIFICATIONS FOR
84 INCH ROTARY MOWER
HEAVY DUTY

1.0 This Specification describes a Heavy Duty Rotary Mower having a cutting width of at least 84 inches. Units furnished to these specifications must meet or exceed all requirements herein.

2.0 EXAMPLES:

Servis Gyro 84 Pull Type
Woods R107
Modern Highway Special

NOTICE TO BIDDERS: Any example shown is listed to show type and class of equipment desired. Bidders are cautioned to read the specifications carefully, as there may be special requirements not commonly offered by the equipment manufacturer. Do not assume your standard equipment meets all detailed specifications merely because it is listed as an example. Bidders are cautioned that units delivered to the F.O.B. points which do not meet specifications is every aspect will not be accepted.

3.0 DESIGN: The mowers furnished under this Specification shall be single spindle Trail Type, constructed to withstand heavy growth right-of-way mowing.

4.0 FRAME AND CAGE: The mower shall have an electrically welded steel frame and shall meet or exceed the following minimum requirements:

4.1 Cage depth minimum: 8 inch.

4.2 Deck thickness minimum: 10 ga. (0.1345 inch.)

4.3 Side skirt thickness minimum: 3/16 inch.

4.4 The front opening shall be enclosed with a single row chain guard and the rear opening shall be enclosed with a double row chain guard.

4.5 The length of each strand of chains shall be such that with the mower set to cut at a height of five (5) inches the bottom link will touch the ground.

4.6 Chain guard rows shall be placed in such a position that under maximum deflection conditions, the chain will not contact the cutting blades.

4.7 A steel cable shall be laced horizontally through the next to the bottom link of each strand. The cable shall be fastened with a cable clamp to the last strand at each end of the opening. In the rear the cable shall be installed in the outside row only.

4.8 The sides of the mower shall be equipped with heavy duty replaceable steel skid plates.

4.9 An adjustable height parking jack shall be furnished.

5.0 AXLE AND WHEELS: The axle shall be the trail type with the wheels mounted to the rear and inside of the cutting swath. Mower total width to be not more than 96 inches.

5.1 The wheels shall be 15 inch drop center type. (Tires are NOT to be furnished.)

5.2 The cutting height adjustment shall be by a ratchet or screw type crank.

5.3 The cutting height range shall be from approximately 3/4 inch to approximately 13 inches.

6.0 DRIVE: The mower drive train shall be designed for connecting to a tractor mounted 540 RPM power take-off.

6.1 The drive train shall consist of a three (3) universal jointed safety shielded drive shaft supported by a tongue mounted carrier bearing, and connected to the mower gear box.

6.2 The gear box shall have an enclosed transmission of heat treated steel machine cut gears, lubricated by oil or grease and shall be rated at a minimum 75 horsepower.

6.3 The gear box shall be sealed and the gears shall be mounted on anti-friction bearings.

6.4 The gear box shall be protected by a slip clutch.

7.0 CUTTING BLADES: The mower blades shall be heat treated steel and shall be the free swinging type which fold back when hitting an obstruction.

7.1 The blade holder may be dish or hub type.

8.0 PAINTING: The unit shall be painted Federal Yellow No. 13538 of Federal Standard 595a except for glass, rubber and those metallic accessories or fixtures constructed of rust-resistant or plated material not normally painted. Lead free paint will be accepted if it matches the color of Federal Yellow No. 13538.

SPECIFICATION NO.
SDHPT-020-16-02
REVISED: MARCH, 1982

9.0 MANUALS: Manual or manuals containing illustrated parts list, operating and service instructions for the mower shall be delivered with each unit. The manual(s) shall be as detailed as possible outlining all necessary service and operating instructions for the unit delivered. Necessary warning and safety precautions shall be included.

10.0 WARRANTY: The unit of equipment shall be warranted against defects in material and workmanship for a period of not less than twelve (12) months. If the manufacturer's standard warranty exceeds twelve (12) months, then the standard warranty period shall be in effect. Successful bidder shall furnish Manufacturer's warranty to receiving District at time of delivery.

11.0 DATA SHEET: The attached Data Sheet must be completed and submitted in duplicate as a part of the bid. Failure to comply may be grounds for rejecting the bid. Information contained therein shall become a part of the contract, if awarded.

12.0 ORDERING DATA: When ordering unit(s) conforming to this Specification, the requisitioning District must specify the following:

12.1 The title and number of this Specification.

12.2 The quantity desired.

12.3 The Option(s) desired.

13.0 MANUFACTURE AND USER REQUIREMENTS: The equipment bid as meeting this Specification must have been in production and offered in regular commercial sales for a period of at least twelve (12) months prior to the date of the Invitation to Bid.

13.1 The bidder shall provide the name, complete address and telephone number of at least three (3) separate agencies or firms which have owned or operated a unit(s) for a period of at least six (6) months immediately preceding the date of the Invitation to Bid. The name of an individual with the agencies or firms that can be contacted for information shall also be provided, if feasible.

SPECIFICATION NO.
SDHPT-020-16-02
REVISED: MARCH, 1982

PART III
84 INCH ROTARY MOWER
HEAVY DUTY
OPTIONAL EQUIPMENT

Optional equipment must be identified on the Invitation to Bid to be required.

OPTION NO. 1

1.0 - Lift Type: The lift type mower shall meet all items in this Specification with the exception of meeting or exceeding the following requirements:

1.1 In lieu of the Trail Type configuration, the mower shall be Lift Type with an A-frame hitch compatible with a tractor Category II three-point hitch.

1.2 The mower shall be equipped with a 360 degree swivel caster trailing wheel(s) with anti-friction bearings, with puncture proof solid, molded rubber or laminated tire(s).

1.3 The cutting height shall be adjustable by the tractor three-point hitch.

1.4 The mower shall have a universal jointed safety shielded drive shaft.

1.5 An adjustable height parking jack shall NOT be furnished.

EXAMPLES: Servis Gyro 84 Lift Type
Woods MR107P
Modern Highway Special Lift Type

NOTICE TO BIDDERS: The above examples are listed as representative of the type and class of equipment desired. Bidders are cautioned to read the Specifications carefully, as there may be special requirements not commonly offered by the equipment manufacturer. Do not assume your standard equipment meets all detailed Specifications merely because it is listed as an example.

OPTION NO. 2

2.0 - Shear Pin Assembly: In lieu of the slip clutch as identified in Paragraph 6.4, the mower gear box shall be protected by a shear pin assembly.

OPTION NO. 3

3.0 - Hydraulic Cylinder: In lieu of the cutting height adjustment as identified in Paragraph 5.2, a hydraulic cylinder for trail type mower(s) shall be provided with wire braid hose identified on SAE Standard J517d or latest revision thereto. The hose shall be of adequate length for connection to hydraulic control at the tractor operator's position.

STATE OF TEXAS
STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION
EQUIPMENT AND PROCUREMENT DIVISION

SPECIFICATION NO.
SDHPT-020-16-04
REVISED: AUGUST, 1985

Does Unit Meet The Purchase Specs?

15-FOOT HYDRAULICALLY DRIVEN ROTARY MOWER

YES/NO

PART I
GENERAL CLAUSES AND CONDITIONS

1.0 The equipment furnished under these specifications shall be the latest improved model in current production, as offered to commercial trade, and shall be of quality workmanship and material. The bidder represents that all equipment offered under these specifications shall be new. USED, SHOPWORN, DEMONSTRATOR, PROTOTYPE, OR DISCONTINUED MODELS ARE NOT ACCEPTABLE. /

2.0 Bidders should submit with their bid, or have on file with the State Department of Highways and Public Transportation, Austin, Texas, the latest printed literature and detailed specifications on equipment the bidder proposes to furnish. This literature is for informational purposes only.

3.0 The unit(s) shall be completely assembled, adjusted, and all equipment including standard and supplemental equipment be installed and the unit made ready for continuous operation. /

4.0 All parts not specifically mentioned which are necessary for the unit to be complete and ready for operation or which are normally furnished as standard equipment shall be furnished by the successful bidder. All parts shall conform in strength, quality and workmanship to the accepted standards of the industry. /

5.0 The unit(s) provided shall meet or exceed all Federal and State of Texas safety, health, lighting and noise regulations and standards in effect and applicable to equipment furnished at the time of manufacture.

6.0 Any variation from these specifications must be indicated on the Bid or on a separate attachment to the Bid. This sheet shall be labeled as such.

PART II
SPECIFICATIONS

1.0 This Specification describes a hydraulically driven fifteen-foot (15') rotary mower consisting of three (3) sections. This trail type mower shall be suitable for mowing extremely heavy grass and vegetation and shall be built from the ground up to withstand the severe service encountered in continuous highway right-of-way mowing. All units furnished to this specification must meet or exceed all the requirements herein.

2.0 EXAMPLE: /

Terrain King Model Hydraulic T.K. 15 Ft.

2.1 NOTICE TO BIDDERS: Any example shown is listed to show type and class of equipment desired. Bidders are cautioned to read the specifications carefully, as there may be special requirements not commonly offered by the equipment manufacturer. Do not assume your standard equipment meets all detailed specifications merely because it is listed as an example. Bidders are cautioned that units delivered to the F.O.B. points which do not meet specifications in every aspect will not be accepted.

3.0 MOWING SECTIONS: Each of the three (3) sections of the mower shall be constructed in heavy-duty fashion and shall have sufficient bracing and/or reinforcement to prevent warping, bending, twisting, cracking or any other type of metal failure from occurring due to the stresses encountered in normal mowing operations. /

3.1 The mower shall be designed to uniformly cut heavy growth at the same set height across the entire fifteen (15) feet and shall not leave an uncut portion between the mower's sections. the mower shall be designed to discharge cut materials from the rear of each section. /

3.2 The side sections shall be connected to the center section by hinges which will allow each section to follow the contour of the land from 60 degrees above to 20 degrees below horizontal when the mower is in the operating (cutting) mode. Hinges shall be constructed of minimum 0.164-inch steel and hinge pin shall be minimum 3/4-inch diameter cold-rolled steel. /

3.3 Drain holes, each measuring approximately 1/2 inch in diameter, shall be provided in the decking material of each of the three (3) sections of the mower. The drain holes shall be arranged, and a sufficient number of drain holes shall be provided, so that water will not stand or puddle on any portion of the mower's deck. /

YES/NO

3.4 The bottom edge of each outer side section of the mower shall be equipped with a replaceable skid shoe. The wearing area of the skid shoe shall be "through" heat treated to a minimum Brinell hardness of 400. The forward portion of each skid shoe shall be sloped approximately 45° above horizontal. Skid shoes and their attaching members shall be designed and/or reinforced to prevent them from being bent and/or broken off during turns that apply side forces to the mower. / / / /

3.5 Each side section shall be capable of being independently raised by hydraulic power controlled from the operator's position. In the fully raised position, the overall mower width shall not exceed 96 inches. It shall be possible to fully raise and lower each side section without disconnecting any of the mower's drive line components. / / /

3.6 Means shall be provided to lock each side section in the raised position for transporting the unit over the road. /

3.7 The mower shall be equipped with a winch and cable for raising each side section in the event of hydraulic failure. Winch shall be equipped with an automatic brake so as to eliminate the possibility of a runaway winch handle or inadvertent descent of a side section. / /

Example: Dutton-Lainson Model No. B-1202, or equal.

3.8 The mower tongue shall be hydraulically actuated to raise the unit for transport. A clevis hitch or captive ball type hitch with clevis pin for connection to the tractor drawbar shall be provided. Hitch shall be designed so as to allow a swing of not less than 30 degrees above and 30 degrees below a horizontal line without binding. / / / /

3.9 The mower shall be equipped with a manually adjustable positive mechanical stop to hold the mower at preset cutting heights without the aid of hydraulic pressure. /

4.0 CUTTER BLADES: The cutter blades shall be free-swinging suction type which fold back when hitting an obstruction. Blades shall be forged or machined of steel and heat treated to a Brinell hardness of 350 to 430. / /

5.0 DRIVE TRAIN: Cutter blades are to be driven by three (3) separate hydraulic motors driven by a hydraulic pump suitable for attachment to a 540-RPM tractor power take-off conforming to SAE/ASAE standards. System to be complete with hyoraulic reservoir of sufficient capacity to prevent overheating, replaceable oil filter, and relief valves to protect against shock. / / / /

6.0 HYDRAULIC SYSTEM: Hydraulic power for raising and lowering outer wings and for adjusting height of mower shall be provided by the tractor hydraulic system. The hydraulic system shall include all necessary hoses, fittings, cylinders and other components required for operation. / /

6.1 Hoses must be equipped with a set of male and female quick couplers and be suitable for connecting to a three (3) spool valve mounted on a tractor. (Three (3) spool valve not to be furnished.) / /

6.2 The quick couplers shall be capable of being connected under pressure. /

Example: Pioneer, or equal.

6.3 The hydraulic hose shall be two (2) wire braid or equal identified in SAE Standard J517a, or latest revision thereto, as SAE 100R2 hydraulic hose. Hose length shall be adequate for proper hook-up and operation of tractor mower combination. / /

7.0 WHEELS: The mower shall be provided with six (6) wheels; one on each side section and two (2) sets of dual wheels on the center section. Size of the wheels and/or tires shall be as specified in Optional Equipment and identified on the Invitation to Bid. / /

7.1 Each wheel shall be equipped with Timken or equal type roller bearings and each wheel hub shall be equipped with a grease zerk fitting for lubrication purposes. A retaining device shall be provided on all wheels to secure the bearings' dust cover to the wheel hub. This retainer shall be designed to prevent the bearings' dust cover from being knocked off by objects encountered during mowing operations. / / / /

7.2 Each wheel shall be capable of being adjusted manually to give the mower a cutting height range from 4 inches to at least 15 inches above the ground. / /

7.3 A spring type suspension assembly on each wheel is required. /

7.4 The wing section wheels shall be located inside the cutting width. /

SPECIFICATION NO.
SDHPT-020-16-04
REVISED: AUGUST, 1985

YES/NO

7.5 Replaceable bushings shall be installed in all axle arm brackets at the axle arm pivot points to prevent the axle arm brackets and axle arms from experiencing premature wallowing out and failure. All axle pivot points shall be held together by bolts with locking nuts. Pins with retaining clips are not acceptable. / / / /

8.0 CHAIN GUARDS: The front and rear openings of all three (3) sections of the mower shall be equipped with a double-row (two (2) curtain) chain guard to provide optimum coverage of the mower's openings. The chain guard shall deflect or minimize the throwing of objects in an outward direction by the cutter blades. Chain guards shall have a steel cable laced horizontally through the next to the bottom link of each strand of chain on the outside row only or some other suitable means such as a rubber shield placed outside of the chain guards to serve as an additional means of deflecting the flight of thrown objects. / / / / /

8.1 Chain shall be at least 5/16-inch welded link. The combined number of strands per foot in the two (2) rows shall be not less than 14. / /

8.2 If the chain guard is not attached directly to the deck, the space between the deck and the chain guard holder shall be filled in with a material suitable to prevent grass being thrown through that space to the top of the deck. /

8.3 The length of each strand of chain shall be such that with the mower set to cut at a height of five (5) inches, the bottom link will touch the ground. The measurement shall be taken under mowing conditions. / /

8.4 Chain guard rows shall be installed in such a position that under maximum deflection conditions, the chain will not contact the cutter blades. /

8.5 The side skirt of each wing section will be of sufficient height or shall be equipped with a single-row chain guard that will provide at least two (2) inches of protection below the plane of blades to minimize objects from being thrown outward by the blades. / /

9.0 SAFETY PLAQUES OR DECALS: Safety plaques or decals shall be furnished and shall be affixed at the operator's station and at any hazardous area. The plaques or decals shall include necessary warnings and precautions. Permanent plaques are preferred to decals. / /

10.0 PAINTING: The unit shall be painted Federal Yellow No. 13538 of Federal Standard 595a except for glass, rubber and those metallic accessories or fixtures constructed of rust-resistant or plated material not normally painted. Lead-free paint will be accepted if it matches the color of Federal Yellow 13538. Examples of paints meeting this requirement are: / /

Du Pont No. 8N552
PPG Industries No. 81958
Sherwin Williams No. 6351

11.0 MANUALS: Manual or manuals containing illustrated parts list, operating and service instructions for the mower shall be delivered with the unit. The manual(s) shall be as detailed as possible outlining all necessary service and operating instructions for the unit delivered. Necessary warnings and safety precautions shall be included. / / /

12.0 WARRANTY: The unit of equipment shall be warranted against defects in material and workmanship for a period of not less than twelve (12) months. If the manufacturer's standard warranty exceeds twelve (12) months, then the standard warranty period shall be in effect. Successful bidder shall furnish manufacturer's warranty to the receiving district at time of delivery. / / /

NOTE: Provisions shall be made by the successful bidder to provide a delayed warranty start date for each unit furnished to this specification. Warranty start date shall be effective the day the completed unit is placed into service. Instructions are to be included with each unit delivered, advising State personnel of the procedures to be followed for obtaining the delayed warranty start date. / / /

13.0 PARTS AND SERVICE: The manufacturer of the equipment furnished shall have an authorized dealer within the State of Texas. The authorized dealer shall have factory-trained personnel available for performance of service. The dealer shall also maintain an inventory of high-usage parts and a quick source for low-usage parts. / /

14.0 REPLACEMENT FILTERS: A complete set of replacement hydraulic filters shall be provided for each unit furnished to these specifications. Each filter shall be labeled with the equipment manufacturer's part number as shown in the manufacturer's parts book and shall be furnished at the time of delivery. The attached Filter Identification Form should be completed and submitted in duplicate for informational purposes only.

15.0 DATA SHEETS: The attached Data Sheet should be completed and submitted in duplicate for informational purposes only. /

SPECIFICATION NO.
SDHPT-020-16-04
REVISED: AUGUST, 1985

YES/NO

PART III
OPTIONAL EQUIPMENT

Optional equipment must be identified on the Invitation to Bid to be required.

OPTION NO. 1

1.0 15-INCH WHEELS: The mower shall be equipped with fifteen (15) inch wheels, less tires. ___/___

OPTION NO. 2

2.0 SOLID RUBBER TIRES: 6.00 x 9 solid rubber tires with tread design. The rubber utilized and tire construction shall allow sufficient cushion affect to absorb approximately 50 percent or more of the shock realized over uneven terrain. The outside diameter of the tire shall be approximately 20 inches. The tires shall be mounted on a two-piece or split type rim. ___/___ ___/___

Example: Bearcat Tire Company Supersoft Grizzley Number SG25, or equal.

OPTION NO. 3

3.0 SOLID OR LAMINATED SOLID RUBBER TIRES: The mower shall be equipped with 6.00 x 9 solid or laminated solid rubber puncture-proof type tires. ___/___

OPTION NO. 4

4.0 SYNTHETIC-FILLED TIRES: 6.90/6.00 x 9 6-ply rating industrial pneumatic tires with tread design complete with wheels. Tires shall be filled with a synthetic rubber compound in lieu of air to provide a puncture-proof capability. The synthetic compound shall be of a density to provide the equivalent of 65 PSI and the tire shall have sufficient cushion affect to absorb approximately 50 percent or more of the shock realized over uneven terrain. The outside diameter of the tire shall be approximately 21 inches. ___/___ ___/___ ___/___

Example: Goodyear Industrial Pneumatic Super Rib filled with permafoam compound, or equal. ___/___

OPTION NO. 5

5.0 24-PLY RECAPPED AIRPLANE TIRES: 9.00 X 12 24-ply airplane tires recapped with truck-tire-grade rubber, mounted on 2-piece bolt-together wheel. Tire to have lug tread design and be furnished with tube and flap. ___/___ ___/___

Example: Martin Tire Co., Jacksonville, Fla.

OPTION NO. 6

6.0 OUTSIDE WING SECTION WHEELS: In lieu of the wing section wheels required to be located inside the cutting width as described in Paragraph 7.4, the wing section wheels shall be located outside the cutting width. ___/___

OPTION NO. 7

7.0 CAPTIVE BALL HITCH: In lieu of the hitch specified in Paragraph 3.8, Part II of this specification, the mower shall be equipped with a captive ball hitch. ___/___

Example: Wood part number 23644, or equal.

OPTION NO. 8

8.0 BALL TYPE COUPLER WITH LOCKING COLLAR: In lieu of the hitch specified in Paragraph 3.8, Part II of this specification, the mower shall be equipped with a ball type coupler having a spring-loaded locking collar. Ball to be provided with coupler. ___/___

Example: Bulldog Model 48-2, or equal.

STATE OF TEXAS
STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION
EQUIPMENT AND PROCUREMENT DIVISION

SPECIFICATION NO.
SDHPT-020-16-05
REVISED: AUGUST, 1985

Does Unit Meet The Purchase Specs?

15-FOOT MECHANICALLY DRIVEN ROTARY MOWER

YES/NO

PART I
GENERAL CLAUSES AND CONDITIONS

1.0 The equipment furnished under these specifications shall be the latest improved model in current production, as offered to commercial trade, and shall be of quality workmanship and material. The bidder represents that all equipment offered under these specifications shall be new. USED, SHOPWORN, DEMONSTRATOR, PROTOTYPE, OR DISCONTINUED MODELS ARE NOT ACCEPTABLE. ___/___

2.0 Bidders should submit with their bid, or have on file with the State Department of Highways and Public Transportation, Austin, Texas, the latest printed literature and detailed specifications on equipment the bidder proposes to furnish. This literature is for informational purposes only.

3.0 The unit(s) shall be completely assembled, adjusted, and all equipment including standard and supplemental equipment be installed and the unit made ready for continuous operation. ___/___

4.0 All parts not specifically mentioned which are necessary for the unit to be complete and ready for operation or which are normally furnished as standard equipment shall be furnished by the successful bidder. All parts shall conform in strength, quality and workmanship to the accepted standards of the industry. ___/___

5.0 The unit(s) provided shall meet or exceed all Federal and State of Texas safety, health, lighting and noise regulations and standards in effect and applicable to equipment furnished at the time of manufacture.

6.0 Any variation from these specifications must be indicated on the Bid or on a separate attachment to the Bid. This sheet shall be labeled as such.

PART II
SPECIFICATIONS

1.0 This Specification describes a mechanically driven fifteen-foot (15') rotary mower consisting of three (3) sections. This trail type mower shall be suitable for mowing extremely heavy grass and vegetation and shall be built from the ground up to withstand the severe service encountered in continuous highway right-of-way mowing. All units furnished to this specification must meet or exceed all the requirements herein.

2.0 EXAMPLES:

Rhino Flex S15
Terrain King T.K.-15 H.D.
Woods HD 315

2.1 NOTICE TO BIDDERS: Any example shown is listed to show type and class of equipment desired. Bidders are cautioned to read the specifications carefully, as there may be special requirements not commonly offered by the equipment manufacturer. Do not assume your standard equipment meets all detailed specifications merely because it is listed as an example. Bidders are cautioned that units delivered to the F.O.B. points which do not meet specifications in every aspect will not be accepted.

3.0 MOWING SECTIONS: Each of the three (3) sections of the mower shall be constructed in heavy-duty fashion and shall have sufficient bracing and/or reinforcement to prevent warping, bending, twisting, cracking or any other type of metal failure from occurring due to the stresses encountered in normal mowing operations. ___/___

3.1 The mower shall be designed to uniformly cut heavy growth at the same height across the entire fifteen feet (15') and shall not leave an uncut portion between the mower's sections. The mower shall be designed to discharge cut materials from the rear of each section. ___/___

3.2 The side sections shall be connected to the center section by hinges which will allow each section to follow the contour of the land from 60 degrees above to 20 degrees below horizontal when the mower is in the operating (cutting) mode. Hinges shall be constructed of minimum 0.164-inch steel and hinge pins shall be minimum 3/4-inch diameter cold-rolled steel. ___/___

YES/NO

3.3 Drain holes, each measuring approximately 1/2 inch in diameter shall be provided in the decking material of each of the three (3) sections of the mower. The drain holes shall be arranged, and a sufficient number of drain holes shall be provided so that water will not stand or puddle on any portion of the mower's deck. / /

3.4 The bottom edge of each outer side section of the mower shall be equipped with a replaceable skid shoe. The wearing area of the skid shoe shall be "through" heat treated to a minimum Brinell haroness of 400. The forward portion of each skid shoe shall be sloped approximately 45° above horizontal. Skid shoes and their attaching members shall be designed and/or reinforced to prevent them from being bent and/or broken off during turns that apply side forces to the mower. / / / /

3.5 Each side section shall be capable of being independently raised by hydraulic power controlled from the operator's position. In the fully raised transport position, the overall mower width shall not exceed 96 inches. It shall be possible to fully raise and lower each side section without disconnecting any of the mower's drive line components. / / /

3.6 Means shall be provided to lock each side section in the raised transport position for transporting the unit over the road. /

3.7 The mower shall be equipped with a winch and cable for raising each side section in the event of hydraulic failure. Winch shall be equipped with an automatic brake so as to eliminate the possibility of a runaway winch handle or inadvertent descent of a side section. / /

Example: Dutton-Lainson Model No. B-1202, or equal.

3.8 The mower tongue shall be hydraulically actuated to raise the unit for transport. A clevis hitch or captive ball type hitch with clevis pin for connection to the tractor drawbar shall be provided. Hitch shall be designed so as to allow a swing of not less than 30 degrees above and 30 degrees below horizontal without binding. / / /

3.9 The mower shall be equipped with a manually adjustable positive mechanical stop to hold the mower at preset cutting heights without the aid of hydraulic pressure. /

4.0 CUTTER BLADES: The cutter blades shall be free swinging suction type which fold back when hitting an obstruction. Blades shall be forged or machined of steel and be heat treated to a Brinell hardness of 350 to 430. / /

5.0 DRIVE TRAIN: Power for the mower drive train shall be provided by a 540 RPM power take-off conforming to SAE/ASAE Standards. Drive lines shall be compatible for use with tractors having up to 75 PTO horsepower. / /

5.1 Power shall be transmitted to a power divider and then to a gear box on each of the three mower sections or shall be transmitted directly to the center section gear box then to each side section gear box. Gear boxes shall be equipped with vents to prevent over pressurization. All vents shall be filtered. / / / /

5.2 The drive shaft to the center section gear box shall be protected by means of a slip clutch or torque limiter having a static breakaway torque of 1,130 ft. lbs. plus or minus 5 %. Each wing assembly drive shaft shall be protected by a slip clutch or torque limiter having a static breakaway torque of 750 ft. lbs. plus or minus 5%. / /

5.3 All drive shafts and clutches shall be shielded or guarded to protect against people contacting rotating members of the power drive system. Each guard and its support shall be capable of withstanding the force that an individual, leaning on or falling against the guard, would exert upon that guard. / /

5.4 The main drive shaft from the tractor power take-off to the mower and the secondary drive shafts to each mowing section gear box shall have "U" joints and yokes as recommended by the manufacturer to meet the requirements of Paragraph 5.0 above. /

6.0 HYDRAULIC SYSTEM: Hydraulic power for raising and lowering outer wings and for adjusting height of mower shall be provided by the tractor hydraulic system. The hydraulic system shall include all necessary hoses, fittings, cylinders and other components required for operation. /

6.1 Hoses must be equipped with a set of male and female quick couplers and be suitable for connecting to a three (3) spool valve mounted on a tractor. (Three (3) spool valve not to be furnished.) / /

6.2 The quick couplers shall be capable of being connected under pressure. /

Example: Pioneer, or equal.

SPECIFICATION NO.
SDHPT-020-16-05
REVISED: AUGUST, 1985

YES/NO

6.3 The hydraulic hose shall be two (2) wire braid or equal, identified in SAE Standard J517a, or latest revision thereto, as SAE 100R2 hydraulic hose. Hose length shall be adequate for proper hook-up and operation of tractor mower combination. / /

7.0 WHEELS: The mower shall be provided with six (6) wheels; one on each side section and two (2) sets of dual wheels on the center section. Size of the wheels and/or tires shall be as specified in Optional Equipment and identified on the Invitation to Bid. / /

7.1 Each wheel shall be equipped with Timken or equal type roller bearings and each wheel hub shall be equipped with a grease zerk fitting for lubrication purposes. A retaining device shall be provided on all wheels to secure the bearings' dust cover to the wheel hub. This retainer shall be designed to prevent the bearings' dust cover from being knocked off by objects encountered during mowing operations. / /

7.2 Each wheel shall be capable of being adjusted manually to give the mower a cutting height range from 4 inches to at least 15 inches above the ground. / /

7.3 A spring type suspension assembly on each wheel is required. /

7.4 The wing section wheels shall be located inside the cutting width. /

7.5 Replaceable bushings shall be installed in all axle arm brackets at the axle arm pivot points to prevent the axle arm brackets and axle arms from experiencing premature wallowing out and failure. All axle pivot points shall be held together by bolts with locking nuts. Pins with retaining clips are not acceptable. / / / /

8.0 CHAIN GUARDS: The front and rear openings of all three (3) sections of the mower shall be equipped with a double-row (two (2) curtain) chain guard to provide optimum coverage of the mower's openings. The chain guard shall deflect or minimize the throwing of objects in an outward direction by the cutter blades. Chain guards shall have a steel cable laced horizontally through the next to the bottom link of each strand of chain on the outside row only or some other suitable means such as a rubber shield placed outside of the chain guards to serve as an additional means of deflecting the flight of thrown objects. / / / / /

8.1 Chain shall be at least 5/16-inch welded link. The combined number of strands per foot in the two (2) rows shall be not less than 14. / /

8.2 If the chain guard is not attached directly to the deck, the space between the deck and the chain guard holder shall be filled in with a material suitable to prevent grass being thrown through that space to the top of the deck. /

8.3 The length of each strand of chain shall be such that with the mower set to cut at a height of five (5) inches, the bottom link will touch the ground. The measurement shall be taken under mowing conditions. / /

8.4 Chain guard rows shall be installed in such a position so that under maximum deflection conditions, the chain will not contact the cutter blades. /

8.5 The side skirt of each wing section will be of sufficient height or shall be equipped with a single-row chain guard that will provide at least two (2) inches of protection below the plane of blades to minimize objects from being thrown outward by the blades. / /

9.0 SAFETY PLAQUES OR DECALS: Safety plaques or decals shall be furnished and shall be affixed at the operator's station and at any hazardous area. The plaques or decals shall include necessary warnings and precautions. Permanent plaques are preferred to decals. / /

10.0 PAINTING: The unit shall be painted Federal Yellow No. 13538 of Federal Standard 595a except for glass, rubber and those metallic accessories or fixtures constructed of rust-resistant or plated material not normally painted. Lead-free paint will be accepted if it matches the color of Federal Yellow 13538. Examples of paints meeting this requirement are: / /

Du Pont No. BN552
PPG Industries No. 8195E
Sherwin Williams No. 6351

11.0 MANUALS: Manual or manuals containing illustrated parts list, operating and service instructions for the mower shall be delivered with the unit. The manual(s) shall be as detailed as possible outlining all necessary service and operating instructions for the unit delivered. Necessary warnings and safety precautions shall be included. / / /

YES/NO

12.0 WARRANTY: The unit of equipment shall be warranted against defects in material and workmanship for a period of not less than twelve (12) months. If the manufacturer's standard warranty exceeds twelve (12) months, then the standard warranty period shall be in effect. Successful bidder shall furnish manufacturer's warranty to the receiving district at time of delivery. /

NOTE: Provisions shall be made by the successful bidder to provide a delayed warranty start date for each unit furnished to this specification. Warranty start date shall be effective the day the completed unit is placed into service. Instructions are to be included with each unit delivered, advising State personnel of the procedures to be followed for obtaining the delayed warranty start date. /

13.0 PARTS AND SERVICE: The manufacturer of the equipment furnished shall have an authorized dealer within the State of Texas. The authorized dealer shall have factory-trained personnel available for performance of service. The dealer shall also maintain an inventory of high-usage parts and a quick source for low-usage parts. /

14.0 DATA SHEETS: The attached Data Sheet should be completed and submitted in duplicate for informational purposes only. /

PART III
OPTIONAL EQUIPMENT

Optional equipment must be identified on the Invitation to Bid to be required.

OPTION NO. 1

1.0 15-INCH WHEELS: The mower shall be equipped with fifteen (15) inch wheels, less tires. /

OPTION NO. 2

2.0 SOLID RUBBER TIRES: 6.00 x 9 solid rubber tires with tread design. The rubber utilized and tire construction shall allow sufficient cushion effect to absorb approximately 50 percent or more of the shock realized over uneven terrain. The outside diameter of the tire shall be approximately 20 inches. The tires shall be mounted on a two-piece or split type rim. /

Example: Bearcat Tire Company Supersoft Grizzley Number SG25, or equal.

OPTION NO. 3

3.0 SOLID OR LAMINATED SOLID RUBBER TIRES: The mower shall be equipped with 6.00 x 9 solid or laminated solid rubber puncture-proof type tires. /

OPTION NO. 4

4.0 SYNTHETIC FILLED TIRES: 6.90/6.00 x 9 6-ply rating industrial pneumatic tires with tread design complete with wheels. Tires shall be filled with a synthetic rubber compound in lieu of air to provide a puncture-proof capability. The syntnetic compound shall be of a density to provide the equivalent of 65 PSI and the tire shall have sufficient cushion effect to absorb approximately 50 percent or more of the shock realized over uneven terrain. The outside diameter of the tire shall be approximately 21 inches. /

Example: Goodyear Industrial Pneumatic Super Rib filled with permafoam compound, or equal. /

OPTION NO. 5

5.0 24-PLY RECAPPED AIRPLANE TIRES: 9.00 x 12 24-ply airplane tires recapped with truck-tire-grade rubber, mounted on 2-piece bolt-together wheel. Tire to have lug-tread design and be furnished with tube and flap. /

Example: Martin Tire Co., Jacksonville, Fla.

OPTION NO. 6

6.0 OUTSIDE WING SECTION WHEELS: In lieu of the wing section wheels required to be located inside the cutting width as described in Paragraph 7.4, the wing section wheels shall be located outside the cutting width. /

SPECIFICATION NO.
SDHFT-020-16-CJ
REVISED: AUGUST, 1985

YES/NO

OPTION NO. 7

7.0 CAPTIVE BALL HITCH: In lieu of the hitch specified in Paragraph 3.8, Part II of this specification, the mower shall be equipped with a captive ball hitch. /

Example: Wood part number 23644, or equal.

OPTION NO. 8

8.0 BALL TYPE COUPLER WITH LOCKING COLLAR: In lieu of the hitch specified in Paragraph 3.8, Part II of this specification, the mower shall be equipped with a ball type coupler having a spring-loaded locking collar. Ball to be provided with coupler. /

Example: Bulldog Model 48-2, or equal.

OPTION NO. 9

9.0 DISH TYPE BLADE HOLDER: A dish type blade holder shall be provided for blade mounting. /