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# AN EPIDEMIOLOGICAL STUDY OF POWER TAKE-OFF ACCIDENTS

by

L. W. KNAPP

LARRY R. PIERCY



*Institute of Agricultural Medicine  
Department of Preventive Medicine and Environmental Health  
College of Medicine*

THE UNIVERSITY OF IOWA · 1966



#### ACKNOWLEDGEMENT

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L. W. KNAPP, Jr., B.S., M.S.

Chief Accident Prevention Section

LARRY R. PIERCY, B.S.

Agricultural Safety Engineer

*Institute of Agricultural Medicine*

*Department of Preventive Medicine and Environmental Health*

*College of Medicine*

FRANKLIN H. TOP, M.D., *Director*

CLYDE M. BERRY, Ph.D., *Associate Director*

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## INTRODUCTION

The many tasks performed by agricultural equipment demand a number of forms of energy to drive its mechanisms. Where electricity is available, electric motors are often used on machines where small amounts of power are required (less than 10 horsepower). If electric power is not readily available or the expense of running wires to the machine is prohibitive, then auxiliary gasoline power will be used. Hydraulic drives are used experimentally (new John Deere self-propelled combines have optional hydraulic drive) but high initial cost precludes any immediate change to this apparently safer way of transmitting power. The evolution of change in transmitting power is likely to be slow, for a great number of existing machines precludes any sudden change to newer and safer methods.

As the size of equipment on today's farm grows larger, greater amounts of energy are required for operation. The needed power and mobility of today's farm tools (self-unloading wagons, portable hammer mills, portable elevators, portable blowers, etc.) preclude any major use of electricity or small gasoline motors to operate such equipment. These problems amply demonstrate why the farm tractor becomes not only the primary mover or major source of power on the farm, but also the major power source for a growing number of implements through use of a "power take-off drive." At present there are approximately 329,000 tractors in Iowa. In the United States, there are 4,790,000 (1) tractors. The extent of the increase in numbers of agricultural equipment is indicated by the table on the following page (Table 1).

TABLE I

A Comparison of the Number and Type of Equipment  
in Use in Iowa and the United States, 1951 and 1960

<u>Type of Equipment</u>	<u>Number in Use</u>	
	<u>1951</u>	<u>1960</u>
Power Elevators		
Iowa	80,000	125,000
United States	479,000	1,180,000
Field Forage Harvesters		
Iowa	6,500	19,000
United States	81,000	300,000
Combines		
Iowa	52,275	101,000
United States	713,633	1,067,000
Corn Pickers		
Iowa	92,516	127,000
United States	455,519	787,000
Pick-Up Balers		
Iowa	13,192 (1949)	59,500
United States	447,941	713,000

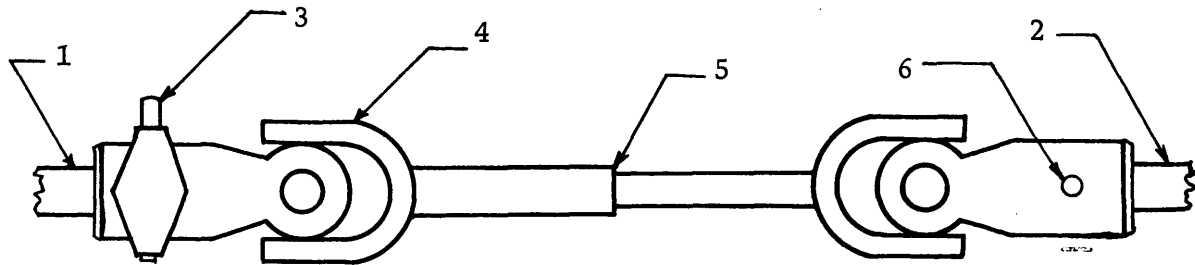
POWER TAKE-OFF MECHANISM:

The power take-off mechanism (referred to as PTO) is a rotating shaft attached to the tractor at one end and the machine to be driven at the other. There is a coupling device for attaching at either end and two or more universal joints which permit the equipment (tractor and attached machine) to turn corners. These universal joints also allow for angular displacement (not straight line) drives. The PTO may, because of the kinds of machines to which it is to be attached, transmit energy varying from fractions of a horsepower to many,



depending upon the rating of the tractor engine which is the power source.

FIGURE 1



- |                                                    |                                                       |
|----------------------------------------------------|-------------------------------------------------------|
| (1) tractor PTO shaft                              | (4) universal joint                                   |
| (2) driven implement shaft                         | (5) telescoping portion of PTO shaft                  |
| (3) spring-loaded pin connecting<br>PTO to tractor | (6) pin and keyway for connecting<br>PTO to implement |

---

The PTO is attached to the tractor by means of a spline collar that slides over the spline shaft protruding from the tractor differential (rear of tractor). This collar is usually held in place by a spring-loaded pin which protrudes from the side of the PTO proper and latches into a recessed area on the tractor spline. The end of the PTO shaft, which drives the machine, may have a variety of attachment principles from a spline and spring-loaded attachment like that on the tractor end, to a round shaft with bolt and key mechanism, to a bolted square shaft. Grease fittings protrude from the side of some of the PTO shafts.

## SHIELDING OF POWER TAKE-OFF SHAFT:

Shielding to prevent accidental contact with the PTO shaft when it is in operation presently falls into two categories, as manufactured by the agricultural machine industry.

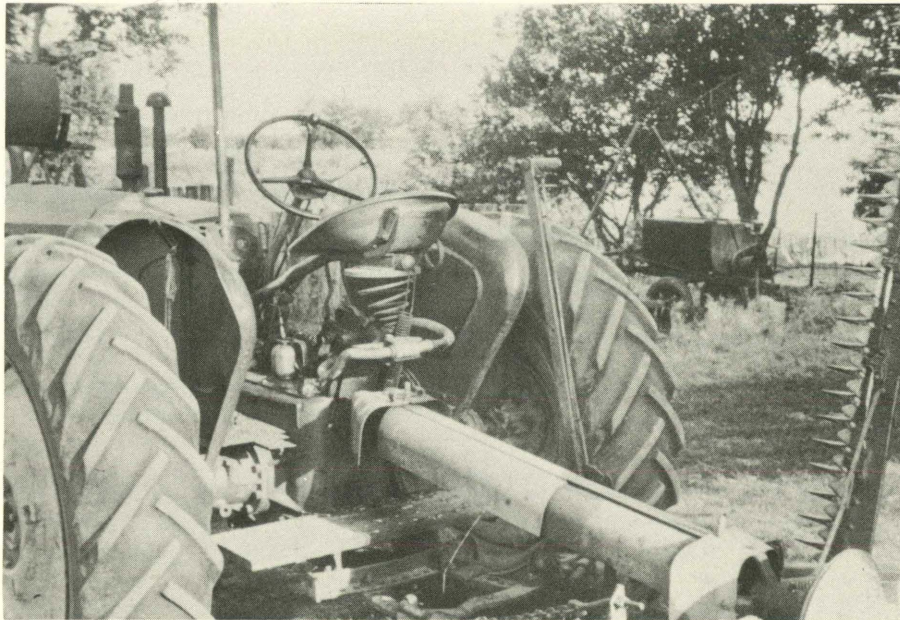


Figure 2: Inverted trough or U-shaped shield connected to tractor master shield and implement stub shield.

1. Inverted Trough, or U-Shaped Shielding Device: The PTO shaft assembly revolves underneath the shield, which is supported at either end, with protection afforded the worker from side or top contact with the rotating shaft.



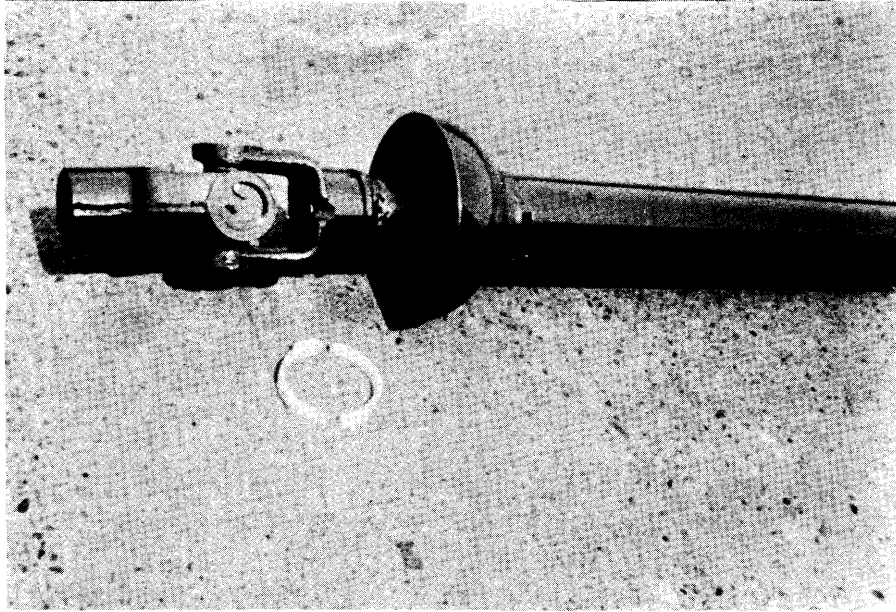


Figure 3: Integral mounted shield disassembled to show nylon bearing.

2. Integral Mounted Shield : The PTO shaft itself supports a tubular shield covering the shaft and universal joints which, when in contact with an object (man) becomes stationary, while the shaft rotates inside of the shield. Bearings separate the shield from the shaft, permitting it to become stationary. The shield also has conical ends which partially cover the universal joints, affording some protection from accidental contact in this area.

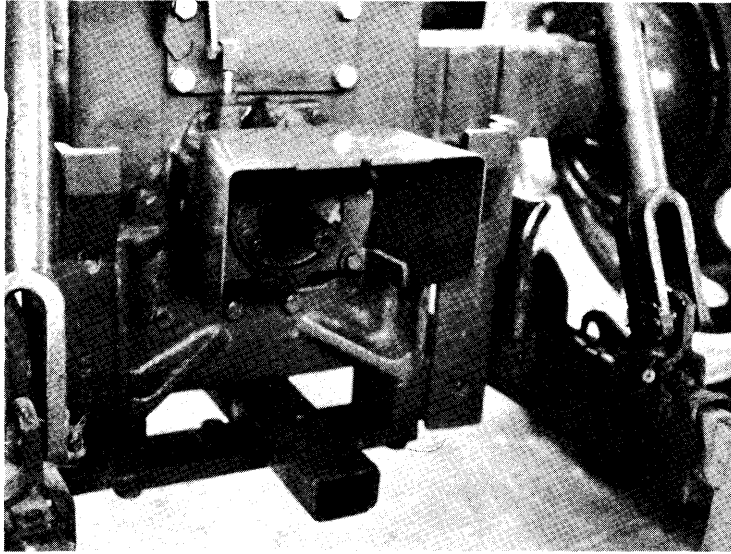


Figure 4: Tractor Master Shield

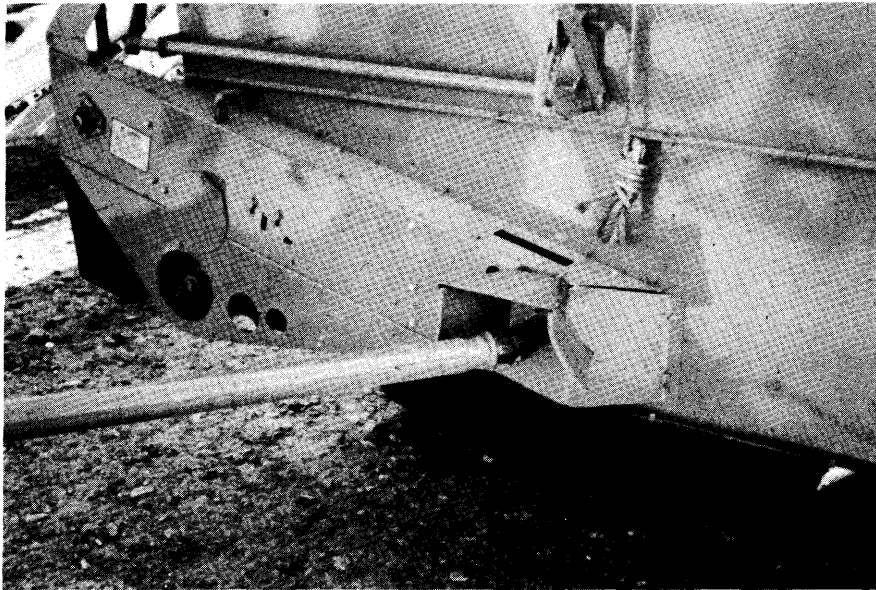


Figure 5: Implement Stub Shield

3. Master Shields and Stub Shields: Master shields on the tractor (Fig. 4) and permanent stub shields (Fig. 5) on the machine are mounted in



such a manner as to protect the exposed splined ends of the PTO shaft when using the integral mounted shield, and serve as mounting points for the inverted trough shield. The stub shield covering the equipment attaching area is usually not as complete as that of the tractor's master shield. The tractor master shield often has to be removed for certain farm operations. It can be damaged accidentally and is often not replaced after removal. The use of the newer integral mounted shield, which needs no outside support as does the inverted trough, also reduces the incentive to replace the shield, once removed.

Considerable angular displacement of the PTO with the line of travel is often required during operation, especially if the machinery is moving about as well as in operation at the time. Such movement establishes the need for considerable clearance between the shield of the PTO shaft and that of the tractor and machine being driven. However, a considerable amount of the PTO exposure time of the worker involves the use of stationary equipment with the farm operator working around the moving equipment and climbing on and off the tractor to start and stop the machinery or adjust its speed. Further, the equipment is so designed and receives the kind of use (hammer mills, grinders, elevators, self-unloading wagons) that it has a longevity greater than the original PTO shielding. It may be used in such a manner and way that a variety of shielding would be required. The clearance to permit this wide diversity of use necessitates an all-purpose master shield on the tractor with such size and clearance (between it and the PTO shielding) as to permit the jamming of

an upper or lower extremity of the body into this clearance area accidentally and is nearly always wide enough to permit the movement of loose clothing into the opening where it can become entangled.

Standard rotational speeds of the PTO are 540 revolutions per minute (rpm) or 1000 rpm on some more recent tractors. The PTO moves in a clockwise direction when viewed from the rear, and may transmit the total horsepower produced by the tractor engine to the driven equipment, depending upon the throttle setting.

Essentially, every PTO accident involves the entangling of the victim's clothing by the rapidly revolving shaft. The speed of rotation of the shaft precludes escape and the power transmitted is so great that there is usually little possibility of engine stall. Possible sequels are the following:

1. The clothing yields, freeing the man without injury.
2. The clothing yields with minimal trauma, such as friction burns, scrapes, sprains, and bruises.
3. The clothing yields and removes loose skin in the scrotal region.
4. The clothing yields following wedging of the victim's body in or against the machine with severe trauma such as lacerations, broken bones, dismemberment of the extremities, or strangulation.
5. The clothing does not yield and the body of the victim is rotated around the shaft with extensive mutilation and early death.

Progress is being made in the shielding of the PTO to prevent clothing entanglement; however, these shields are frequently removed by the farmer and in some instances do not adequately protect the operator. Among safety people familiar

with farm accidents, the PTO mechanism is considered a highly dangerous portion of the machine.



## RESEARCH PROCEDURE

### RESEARCH PLAN:

In the spring of 1962, a research grant was obtained from the United States Public Health Service to study power take-off accidents. The purpose of this study was to conduct a one-year pilot study into the causes of PTO accidents through epidemiological case investigation of such accidents in the state of Iowa. The objective of this study was not to determine the incidence of injury to a segment of the population, but to develop a means of injury prevention from detailed investigations of these accidents by instituting a pilot study.

The pilot study was started in June of 1962, and the first two and one-half months were spent in developing a state-wide system of reporting PTO accidents. The case investigation phase was initiated in the latter part of August. A few accidents had been investigated prior to this time to gain procedural experience and to evaluate techniques for determining basic causes.

Because of the success of the initial investigation phase of the pilot study, the research grant was renewed at the end of the first year and the investigative phase continued uninterrupted. The grant renewal also provided for a laboratory study and a job analysis of work patterns observed in using PTO equipment. A total of 110 accidents which occurred during the first 20 months of the investigational phase will be discussed in this bulletin.

### DEFINITION OF A PTO ACCIDENT:

For the purpose of this study, PTO accidents were divided into two categories.

1. Professional medical treatment required due to an injury received from the PTO assembly which did not involve entanglement of clothing
2. Clothing entangled in the PTO, or a revolving shaft, regardless of whether an injury resulted.

#### REPORTING SYSTEM:

The first phase of this study was to establish a comprehensive system for reporting PTO accidents occurring in the state of Iowa. To do this, 140 hospital directors and 100 county extension directors were personally contacted and the project outlined to them, asking their assistance in reporting the defined accidents. In a few instances, where it was not possible to make immediate personal contact with the reporting source, a letter explaining the project was sent, asking for initial cooperation. In addition, subscriptions for 111 weekly and 14 daily newspapers covering the state were entered to obtain information on accidents that might otherwise be missed. It was hoped that all serious accidents would be reported by hospitals and that county extension directors, through their extension councils and personal contacts with farmers and rural sources, would be able to report on accidents not requiring hospitalization, but which had received attention in doctors' offices or had been given first aid at home.

The reporting source was to inform the Institute of a PTO accident on a postage-paid self-addressed double card (see Appendix 1). The card was designed, on folding, to keep the victim's name and address and any additional information confidential. In addition to the primary information of name, address, and type of machinery

involved, a space was left to describe the type of injury and the circumstances of the accident. The victim's telephone number was included to facilitate contacting the victim and arranging for an interview.

Initiation of reporting occurred in August, 1962, and three major problems were encountered rather soon. First, sole use of correspondence as a means of acquiring initial cooperation with reporting sources proved to be very ineffective when compared with personal contact. Many did not reply to inquiries, and when response occurred, reports were frequently inadequate. Secondly, there was the problem of defining the specific type of agricultural accidents of interest when talking with individuals with a non-agricultural background. In spite of an explanation of the type of accident desired, using such terms as "entanglement of clothing" and "revolving shaft," approximately two-thirds of the accidents reported in the first year were not in the PTO category. In some instances it was difficult to distinguish between the two unless the victim was contacted, which proved very time-consuming. It was soon apparent that regular visitation to the reporting sources was necessary in order to maintain adequate reporting of accidents, as

1. personnel changes took place at hospitals,
2. supplies of reporting cards were lost or destroyed,
3. questions on reporting needed to be answered,
4. regular personal contact improved cooperation,
5. accidents overlooked in reporting were often recalled, and
6. the quality of reporting was improved (fewer non-PTO accidents reported).



Regular progress reports were sent to all cooperating reporting sources in addition to the personal visits.

Soon after the project was underway, it was apparent that we would not secure a complete reporting of all PTO accidents, and this was verified when we cross-checked our numbers reported by sources. Of 67% of victims hospitalized, only 40% were reported by the hospitals involved.

The problem of complete reporting was further emphasized by analyzing the figures from a six-county "intensive reporting" project using doctors as reporters, in which only 40% of the PTO injuries were hospitalized, the doctors treating the other 60% in their offices or at the victim's home. A majority of minor injuries are obviously going unreported and consequently, accidents discussed in the bulletin should not be considered the sum total of those occurring in Iowa.

#### ACCIDENT INVESTIGATION:

The investigative phase of the study was carried out in a manner similar to that used by Knapp (2) in "The Epidemiology of Tractor Accidents." This consisted of determining the ultimate as well as the proximate causes of the accident as influenced by man, the machine, and the environment. Such information was obtained through personal interviews with the accident victims, witnesses of the accident, attending physician, or county medical examiner. The accident scene and injury-causing equipment were inspected by the investigator, and photographs taken when possible. (Appendices 2 and 3 illustrate such investigations.)

After a number of investigations were completed, an accident analysis form (Appendix 4) was developed to help the investigator record some of the routine facts

to be used at a later date. The form was not designed to be a complete accident report, but instead to condense certain portions and serve as a supplement to the primary written report.

## ANALYSIS OF 110 ACCIDENT INVESTIGATIONS

The 110 PTO accidents summarized herein were investigated between August, 1962 and April, 1964, and were separated into two basic categories, as used in defining the PTO accident.

1. Professional medical treatment required due to an injury received from the PTO assembly which did not involve entanglement of clothing.
2. Clothing entangled in the PTO, or a revolving shaft, regardless of whether an injury resulted.

### CATEGORY 1 ACCIDENTS:

The first accident category involved 10 of the 110 PTO accidents, six of which occurred when the telescoping portion of the PTO was extended too far, allowing the shaft to come apart. This swinging shaft struck the operator, causing injury. In two instances, bolt failure allowed the PTO to become disconnected and swing in an arc, striking the operator. In the remaining two instances, one operator caught the heel of his shoe under the inverted trough shield, causing him to fall and fracture his ankle. The other victim fell on an integral mounted shield, injuring his hip.

### CATEGORY 2 ACCIDENTS:

The second category, to which this bulletin is primarily addressed, are those accidents in which the clothing became entangled, numbering one hundred. As these 100 PTO accidents occurred with many types of PTO equipment commonly used on the midwestern farm, the equipment was divided into three sub-groups according



to how it was being used.

Classification of Equipment: The first group involved stationary equipment such as grinders, hammer mills, and elevators, which are used only in a stationary position. The second group included auger wagons, forage wagons, sprayers, etc., classified as semi-stationary, for they could be operated while in a stationary position, or function while moving. The third group, non-stationary, consisted of such equipment as corn pickers, combines, or mowers that accomplish their function while in motion.

TABLE II

<u>PTO EQUIPMENT BEING USED AT THE TIME OF THE ACCIDENT</u>		
<u>Equipment</u>	<u>No. Accidents (sub-total)</u>	<u>Total</u>
<u>Stationary</u>		44
Grinders and hammer mills	18	
Elevators		
1. PTO	13	
2. Tumbling rods	8	
Post hole diggers	2	
Other	3	
<u>Semi-Stationary</u>		27
Silage wagons	10	
Auger wagons	8	
Sprayers	7	
Other	2	
<u>Non-Stationary</u>		29
Corn pickers	11	
Combines	4	
Mowers	3	
Manure spreaders	3	
Other	8	

Table II indicates that PTO equipment with the greatest risk for injury was the stationary group. The following four factors explain, in part, some of the operational problems associated with the use of this category of equipment that makes this so.

1. When operating stationary equipment, it is necessary to work around the running PTO, for the tractor serves as a stationary power source.
2. Tractors which must be mounted from the rear make it necessary for the operator to come into very close contact with the PTO at least twice during the operation; first when starting the machine, and second when stopping it.
3. This type of equipment is used for relatively short periods of time but frequently throughout the year. Thus, high annual use in terms of operator hours and proximity of the operator to the revolving shaft gives this equipment a very high exposure rate.
4. Environment is an important factor since machines, especially burr grinders and hammer mills, are used throughout the year, and a wide variety of weather conditions are encountered. The majority of accidents involving this type of equipment occur during the late fall, winter, and early spring, when snow, ice, and mud make footing uncertain. Quite often the type of material being handled (e.g., ear corn scattered around the equipment) may cause the operator to lose his footing.

Semi-stationary equipment presents problems similar to those encountered with

stationary equipment, especially when it is used in connection with livestock feeding. Frequent, even daily, use; environmental conditions, particularly mud and snow in feed lots; and the necessity to work around the PTO while it is operating are all factors similar to that of the stationary equipment. Most of the accidents with semi-stationary equipment occurred when the equipment was not moving but the operation made it necessary to have the PTO running. However, in a few instances, the accident involved the equipment while in transport - a passenger riding the tractor became entangled in the PTO.

Generally, accidents occurring with non-stationary equipment do not occur while the machine is performing its primary function. Rather, they occur when there has been a stoppage or malfunction which requires the victim to dismount and allow the PTO to run in order to determine the cause of the malfunction. In only 12 instances did accidents occur when there was no specific reason for leaving the PTO running, and these resulted when the person was in a hurry and did not take the time to disengage the PTO.

Seasonal Variation: Seasonal variation in the number of accidents has not been as great as might have been expected. The months of October and November had the highest number of accidents ( 9 and 10 accidents respectively) but this can be attributed in a great part to the increased exposure due to corn harvesting activities. However, the number of accidents reported in this study remained quite constant throughout, with an average of 5 accidents per month. During the late fall, winter and spring, chore equipment (feed grinders, unloading wagons) accounted for a large portion of the reported accidents. In spring and summer, forage harvesting equipment



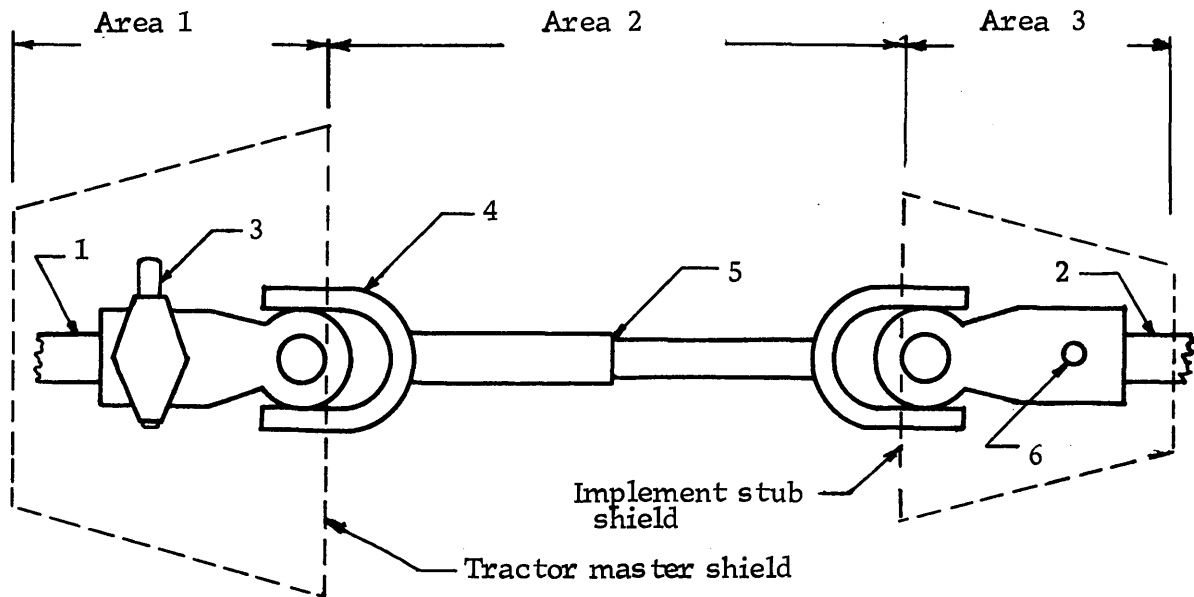
such as mowers and hay conditioners, combines harvesting small grain, and the miscellaneous equipment such as fertilizer spreaders, manure spreaders, and sprayers accounted for most of the accidents.

Shielding: The 100 accidents in category 2 were further classified into three groups with respect to the amount and kind of shielding covering the PTO at the time of the accident. They are as follows:

1. All shielding recommended by the manufacturer in place.
2. Part or all shielding recommended by the manufacturer missing.
3. Shielding not designed to attach to revolving shaft.

In group 1, with 21 accidents, the largest portion (13) occurred when the revolving shaft was equipped with the integral mounted shield and the tractor master shield was in place. Further, these 13 accidents occurred in two areas (see Fig. 6 on the following page). Area (1), where the master shield and the integral safety shield are joined, and area (3) where the PTO assembly is attached to the driven machine. Those which occurred at area (3) were the result of lack of or inadequate shielding.

FIGURE 6  
DIAGRAM OF PTO



- (1) tractor PTO shaft
- (2) driven implement shaft
- (3) spring-loaded pin connecting PTO to tractor
- (4) universal joint
- (5) telescoping portion of PTO shaft
- (6) pin and keyway for connecting PTO to implement.

Area (1) is the portion of the PTO which attaches to the tractor's PTO shaft. The most common type of coupling device is the spring-loaded pin. Bolts and cotter pins are also used occasionally. This portion of the PTO is intended to be shielded by the tractor master shield.

Area (2) is the portion of the PTO between the universal joints shielded by the inverted trough shield or the integral shield.

Area (3) is the portion of the PTO which attaches to the implement, and may be covered by a stub shield mounted on the implement. Attachment is usually accomplished by bolt or cotter pins.

Another four accidents occurred with equipment which had a master shield and an inverted trough shield in place. In these instances, loose clothing was either accidentally flipped under the shield, or the shielding did not extend far enough to the rear to fully cover area (3) in Figure 6. Of the remaining four cases, two are worthy of note, for the PTO was covered by an improperly attached shield, and yielded when the victim leaned against it.

In group 2, 67 accidents occurred because one or all of the manufacturer's available shields were missing. In 17 cases the PTO drive was protected by an integral mounted shield, but the accident resulted because the tractor's master shield was not in place. In another 16 instances the tractor's master shield was missing and the operator's clothing became entangled in area (1), Figure 6, although the inverted trough shields for areas (2) and (3), Figure 6, were also missing. Thirty-one of the 67 accidents occurred in areas (2) and (3), Figure 6, because inverted trough shields were missing. (This assumes that the missing shielding would have adequately covered all of area (3), Figure 6.) Of these 31 accidents, five involved equipment which had been built by the farmer and although they were not shielded, they were standard PTO drive assemblies and could have been shielded if desired. The remaining three accidents resulted from: (a) a nylon bearing wearing out and allowing the integral mounted shield to slide back, (b) a bolt breaking on the shield, exposing the PTO, and (c) no provisions for a stub shield on the machine, even though an integral mounted shield was available from the manufacturer for the drive line.

In group 3, there are 12 accidents in which clothing became entangled in a revolving shaft (not a typical PTO assembly) for which standard PTO shielding was

not available. This group was made up primarily of elevator tumbling rods and stub shafts which protruded from the elevator boot.

Point of Entanglement: Up to this point, only the location where the clothing became entangled has been discussed. Although it is usually evident that the clothing first became entangled on a protrusion from the PTO shaft, such as a bolt, pin, or spring-loaded pin, it is often impossible to make a positive identification of the offending part. This is usually the case when it is necessary to unwrap the clothing to free the victim and the rescuers failed to note how the clothing was wrapped about the PTO, concern being with the injured person. During an investigation, the victim might refer to the clothing becoming entangled in the universal joint, but upon inspection, a more specific determination was made.

Table III lists the parts of the PTO assembly which were involved in clothing becoming entangled and which resulted in a PTO injury.

TABLE III  
PORTION OF PTO WHICH ENTANGLED VICTIM'S CLOTHING

<u>Part</u>	<u>Number</u>
Bolts, cotter pins, pins, nails	42
Spring-loaded pin	30
Grease fitting	9
Smooth shaft	4
End of stub shaft	4
Universal joint	1
Unknown	8



equipment without shields for short periods of time.

Work Pattern: The man's "work pattern"\* around the PTO equipment plays a very important role in PTO accidents. In addition to the information on work patterns obtained from the accident investigations, a limited study of work patterns around elevators and other chore equipment was made. From these sources it appears that there really isn't any given work pattern for an agricultural machine, as compared to the routine in an assembly line in industry. It was found that the work pattern was continually being interrupted by clogging of the machine, chasing livestock away from the work area, and interruptions by wife, children, or hired help. Other factors, such as the type of equipment and where it is being used, also influence how it is used. Work paths around equipment may be relatively safe under conditions when there is good footing, but under adverse environmental conditions (poor footing) the same work patterns may become very hazardous and, in an emergency, the victim may revert to work patterns developed with other equipment which is not suitable for the situation at hand. Thus, it must be realized that the man's work patterns which may bring him close enough for his clothing to become entangled in the PTO are influenced by many variables which include the machine he is using, the environment in which it is being used at that time, and both the physical and mental state of the operator at any particular time. These factors must all be taken into consideration if one is going to understand some of the reasons for the man's actions.

---

\*Work pattern defines operator activity with respect to use of a machine.

accidents involving younger children whose clothing became entangled in the PTO. Of the 110 PTO accidents, 11 were youngsters 14 years of age and under. The youngest was three years old. In eight of these, an adult was nearby and presumably aware of the potentially dangerous PTO and the youth's exposure, but made no known effort to warn or remove him from the area. In the remaining accidents, numbering three, the youth approached the PTO without the knowledge of the operator, again demonstrating how casually this potentially dangerous equipment is often used on the farm.

It was noted by Thomas McCorkle (4) that generally speaking, the farmer had been trained from childhood with the concept that, while he should avoid injury when possible, he should not be especially cautious because "he won't get anything done."

Another factor is that most farmers who have been farming for 15 years or more have at some time in their lives worked with PTO equipment for which there was no shielding. Although this is not a reason for not using proper shielding, it does help to explain why some individuals may not be as concerned about the unshielded PTO.

Part of the problem may be due to the fact that the farm operator views the PTO as just one of many dangerous pieces of equipment which is necessary to "get the job done." With the increasing use of PTO chore equipment which may be used once a week or as much as twice a day, the danger of the PTO becomes less apparent. With increased usage, it would appear the farmer becomes more tempted to leave the shield off when he is in a hurry, reasoning that he will only be using it a short time and he will be careful. In fact, it appeared that most operators will use PTO

victim continued to use the equipment without shielding, and indicated that he was "more careful."

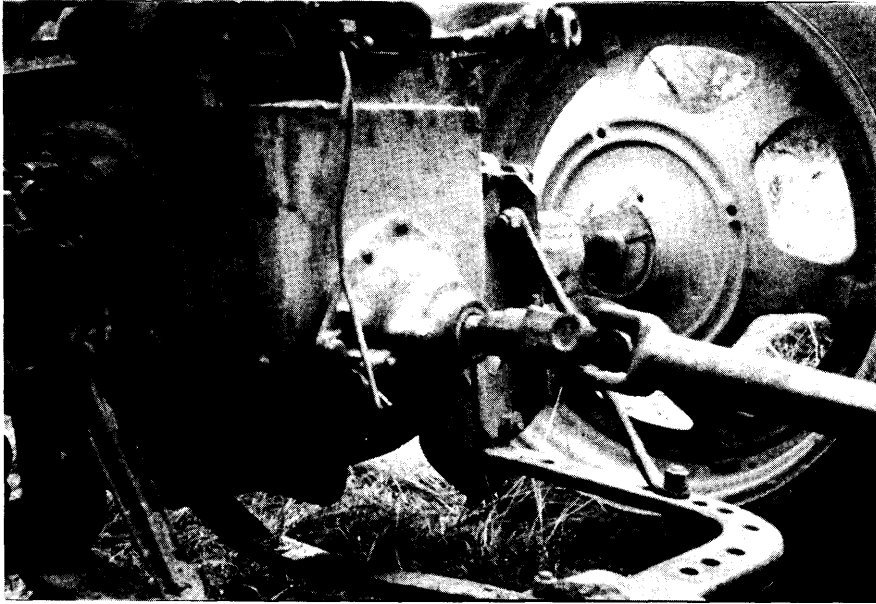


Figure 11: A 17 year old boy was injured as he stepped across the PTO of the above equipment from the right side of the drawbar to disengage the PTO by depressing the lever with the heel of his shoe. The spring-loaded pin caught the cuff of his overalls, hospitalizing him for two days with extensive skin abrasions.

It would appear that this attitude toward accidents, more than any other single factor, would exemplify the magnitude of the problem of working with the "man" in the prevention of PTO accidents. Another example of this was the case in which the victim's clothing had become entangled in the same piece of equipment under identical circumstances for the second time. Thus, even the supposed ultimate in education - experiencing such an accident personally - is not sufficient to override other imposing factors to which the man gives greater attention than to his own safety.

For a deeper insight into the "man", mention should be made of some of the

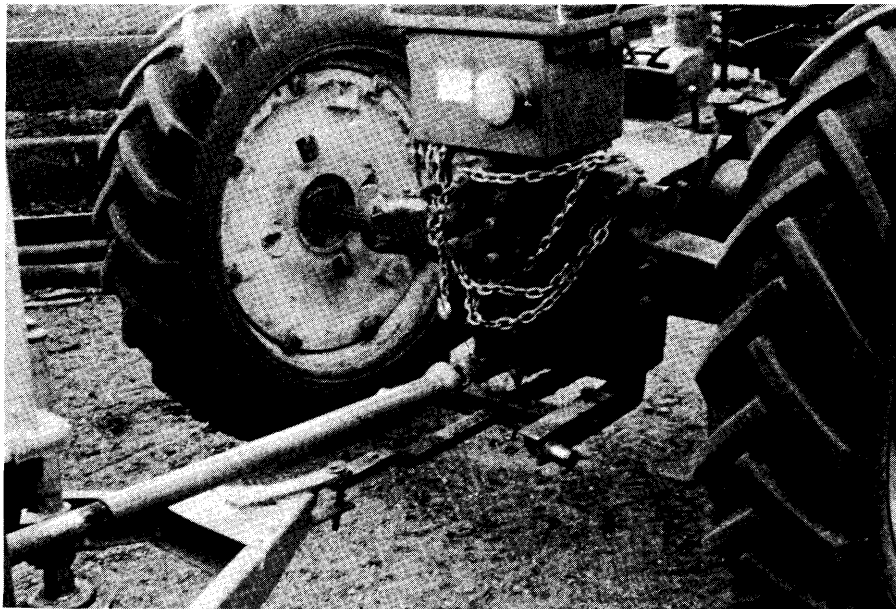


Figure 10: Example of chore equipment with integral mounted shield, but the tractor master shield is missing.

The integral mounted shield, unfortunately, is considered as the ideal PTO shield by many users. In fact, when the inverted trough shield was missing and an accident resulted, regardless of the point of entanglement, the victims often mentioned this type of shielding as a means of prevention. Although they realize the danger of the spring-loaded pin and other coupling devices, their first thought seems to be that the shaft and universal joints (which are only partially covered by this type of shield) are the danger spots. For this reason, it should be noted that when this portion of the PTO is shielded, small unshielded portions are not perceived as a hazard by the operator.

It was noted in the investigations that in half of the accidents where the inverted trough shield was missing, the victim continued to use the equipment without shielding. an example is illustrated by Figure 11 on the following page, where the father of the



3. There was no shielding when the machine was purchased.  
(occasionally true of new equipment, but more often applies to used equipment)
4. The shield was old and would no longer stay in place.
5. After the shield broke, the farmer "just never took the time to fix it."
6. "I never used the shields, I just always stayed away from the PTO."

Indications are that the operators were more apt to use the inverted trough shield on equipment which would be used for major farming operations such as combining than on other equipment, because such equipment requires considerable set-up and adjustment prior to use as opposed to chore equipment where there is only hook-up time prior to use.

Getting the operator to use the master shield provided is still another critical problem. Since the development of the new integral mounted shield, which requires no external support, and since some mounted equipment (weed sprayers) requires removal of this shield, it appears that once the shield is removed, there is little incentive for a man to replace it. Also, the man tends to place complete confidence in the integral mounted shield, overlooking what, in our study, appears to be the real danger spot of the PTO. Although in a few cases the master shield was broken, generally the man was unable to give any reason for not using the shield other than "just not taking the time to replace it."

implies the expectation that the man must exercise a constant alertness and must perceive and avoid all possible accident situations. Also germane to "carelessness" are the suggestions made to farmers for the safe use of PTO equipment. These safety suggestions are oftentimes general and meant for ideal conditions. However, anyone who has worked with farm machinery can attest to the fact that conditions are quite often less than ideal. It is not always practical for the operator to follow the suggested safe practices. For instance, in the past the operator has been told to "turn off the PTO before dismounting from the tractor." However, with chore equipment\* this is not possible. In fact, even with the cornpicker and other pulled equipment, the operator finds it necessary to dismount and check the machine while it is running. Another common safety suggestion warns the operator, "Do not wear loose clothing around the PTO." However, if he is doing strenuous physical labor, he may not or will not keep his jacket fastened when he begins to perspire.

Safety Attitude: Needless to say, the biggest problem with the man involves his use of PTO shielding. It is common knowledge that the first PTO shielding, the inverted trough shield, was not well accepted by many of its users. The most common criticisms and reasons for not using the shield were:

1. They are hard to fasten and troublesome when repeatedly hooking and unhooking to an implement (skinned too many knuckles and required too much time).
2. After being used for a while, they became bent and would no longer telescope.

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\* Chore equipment is defined in this bulletin as feed grinders, grinding-mixing equipment, and self-unloading wagons.

## MAN - MACHINE - ENVIRONMENT

### THE MAN IN THE ACCIDENT:

The Man must be considered as the sum of his physical being. Such includes any handicaps, his responses, both learned and automatic, and his behavioral patterns when around his equipment (3). Just as real, but often not apparent, are the psychological and physiological aspects of the man. The mental strain of "getting the job done," preoccupation with the weather, mental frustrations associated with the operation of the machinery, coupled with the environmental conditions of heat, cold, as well as weariness, all reduce his mental capabilities.

Age, physical and mental handicaps were encountered in a few of the victims. Agriculture, unlike industry, has no screening or selection of workers to insure proper job assignment. In the accidents investigated, youngsters of ages 5 to 16 with only limited experience and knowledge of the danger of the PTO mechanism were involved. At the upper end of the age scale are those who have had previous experience with the equipment, but have slowed reaction times and lack agility under conditions of poor footing. In other instances, physical deformities hampered the operation. Mentally retarded and mentally disturbed were also encountered in a few of the investigations.

Such factors are often overlooked by the casual observer and the victim is considered to be "just careless." Such a statement does not allow for human error, and ignores completely any possible machine or environmental factors which may have precipitated and/or contributed to the accident greatly. The use of such a term

arrived. The fourth victim died of chest injuries soon after arriving at the hospital, and the fifth fatality resulted when an elderly person received a severe leg laceration and lay injured in the field for two hours before discovery. He died following removal to the hospital.

It is apparent that immediate medical attention for accident victims is very critical and indications are that in several accidents the victim's life was saved because there was another person present and medical aid obtained quickly.



below the knee in two cases, and loss of an arm just below the shoulder in two instances. Amputation of limbs occurs in two ways. First, and most often, the limb is traumatically amputated or nearly amputated at the scene of the accident. Secondly, amputation of the limb may be necessary to save the victim's life because of infection. The infection is the result of large accumulations of dirt and foreign material that are inadvertently brought into contact with the wound and imbedded in the flesh at the time of the accident, and during the activity of freeing the victim.

Joint separations and dislocations are not common PTO injuries, but when they occur, it often results in extended periods of disability for the victim. The most common injury of this sort is a shoulder dislocation. In cases of extreme shoulder separation, activity of the injured has been limited for periods of up to five months.

Another type of injury associated with PTO accidents is strangulation. One of the fatalities was the result of clothing gathered tightly about the neck. In several other accidents, similar circumstances occurred, but at the time, the victim was working with another person, who was able to free him and prevent strangulation. In one accident, where all of the clothing was torn off, the victim recalls that some of the clothing gathered around his neck and choked him before tearing free.

PTO accidents resulted in five fatal injuries. In two cases a severe chest injury and strangulation resulted in the immediate death of the victims, although neither body was discovered until several hours after the accident. In a third instance, the victim was found alive three or four hours after the accident occurred, but died from chest injuries and exposure to 30° temperature before a physician



Figure 9: X-rays of fractures of the humerus of the same 7 year old boy.

An injury unique with the farm worker and associated with and typical of PTO accidents is emasculatation or loss of skin from the scrotum and penis. This type of injury occurred in six accidents. In several cases the injuries were primarily lacerations to the scrotum and penis, and in the remainder, the injuries ranged from partial to total loss of skin from the scrotum and penis. None of these accidents resulted in the loss of or permanent damage to the testicles, although surgeons report that this occasionally occurs. From the very limited number of such accidents in this study, it appears that it usually occurs when a person, stepping over the revolving shaft of the PTO, falls astride it.

Amputation of limbs has long been associated with injuries from PTO accidents; five such accidents were recorded, loss of a foot in one case, loss of a leg just

and although not hospitalized, he had to be treated daily by a physician for two weeks and was disabled for a total of 38 days.

Fractures are another very common injury resulting from PTO accidents. They often are compound and multiple fractures which can result in extended periods of disability. The longest fracture disability recorded in this study was approximately 18 months. This involved a compound comminuted fracture of the tibia and fibula (see Appendix 2 for details and X-rays). An uncle's description of the accident documented in Figures 8 and 9 was, "The boy's glove caught on the PTO and the arm was wrapped around the PTO like a wet noodle."



Figure 8: X-rays of fractures of the radius and ulna and an unseen "green limb" fracture.

by hospitals.

The type of injuries sustained from these accidents vary greatly. Although fatalities and amputation of limbs are commonly associated with PTO accidents, lacerations and fractures are far more frequent. The injuries listed in Table V are only those which required professional medical treatment.

TABLE V  
TYPE AND LOCATION OF INJURIES

<u>Location of Fractures</u>		<u>Location of Lacerations</u>	
Upper extremities	12	Upper extremities	7
Lower extremities	18	Lower extremities	34
Ribs	10	Other	9
Other	<u>5</u>		
Total	45	Total	<u>50</u>

Severe Abrasions and Bruising	29
Shoulder Dislocation	7
Denuding of Testes and Penis	6
Brain Concussion	5
Amputations	
Lower extremity	3
Upper extremity	2
Other Injuries	15

Skin abrasions and contusions are the trade-marks of the PTO accident. Even in accidents not requiring medical treatment, the victim usually had some skin abrasions and was bruised and stiff for several days after the accident.

Lacerations received as a result of a PTO accident are usually severe and require suturing. They generally occur to the lower extremity at the location on the body where the clothing first became entangled. An example is a victim whose only injury was a large laceration to the lower part of the leg requiring 35 sutures for closure,

There is little indication to date that the condition of the clothing has any major effect upon the accident. In only a small percentage of the accidents was the presence of a cuff or loose patch or hole in the clothing believed to have caused the entanglement.

Where the side could be determined, 41 of the 71 accidents occurred on the left side (from the rear of the PTO, facing the tractor's PTO). It is not known how many of the men involved use this side only, or a majority of the time, for mounting or dismounting the tractor.

Presently, many farm workers wear nylon insulated clothing which is light-weight, very warm, and extremely difficult to tear. Frequently, when the victim has been wearing this type of clothing, he commented on the difficulty of its tearing free of the body and believed that it was partially responsible for the severity of his injuries.

It would appear that the speed of the PTO shaft may be related to the severity of the injuries and be directly associated with the tearing of the clothing. In 18 instances the PTO was running at a rather low speed (less than half throttle) and the tractor engine stalled when the clothing became entangled, resulting in severe injuries. However, the contribution of the speed factor has not been determined.

Injuries: As has been noted earlier, over 67% of the accidents investigated required hospitalization. Of those remaining, 20% were treated by a physician, 10% required only at-home first aid treatment, and 2% were fatal at the scene. The large percentage of accidents resulting in hospitalization can be partially attributed to the type of reporting system used, which relied heavily upon reporting of accidents



Generally, when the person wore lighter clothing during the warmer seasons of the year, he was able to hold onto a part of the machinery while his clothing was being forcibly torn away. This personal action was usually possible only when the pant leg was the first article of clothing to become entangled in the PTO. Also, it usually removed only the clothing below the waist, occasionally only one pant leg. However, if the person was wearing a coat and it became entangled, even though light, the injuries tended to be more serious, for the victim was usually unable to retain his balance.

During the winter season when heavy clothing is being worn it is much more difficult for the individual to maintain an upright position, even though attempting to hold onto the equipment, for several layers of clothing must be removed before he is free. If he loses his balance and is thrown against the equipment or around the PTO shaft, the injuries will be very extensive. During such an accident most of the clothing is torn off unless the tractor stalls. This type of accident results in multiple lacerations, compound fractures, and amputation or loss of life.

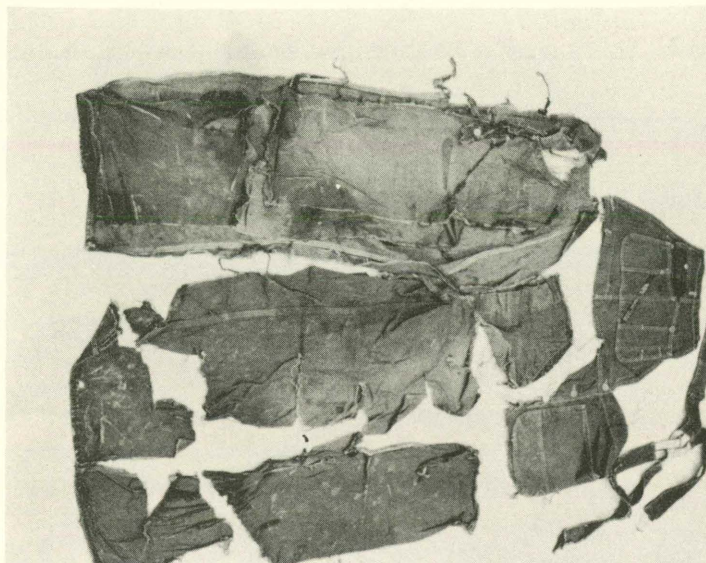


Figure 7: Torn clothing.

TABLE IV  
ENTANGLEMENT BY TYPE OF CLOTHING WORN BY VICTIMS

<u>Clothing first entangled</u>	<u>Number</u>
Overalls and/or coveralls	55
Western jeans	15
Wash pants	5
Other	17

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As noted in Table IV, overalls and coveralls are involved in the majority of the accidents. The seventeen accidents involving "other" types of clothing such as jackets, sweat shirts, and shirts, generally occurred because the clothing was unbuttoned and free swinging. This factor will be discussed later in the section entitled, "The Man in the Accident." Most of the accident victims who were wearing the western style of tight fitting jeans were under the age of 20.

It has been observed that the type and extent of injuries vary with the amount of clothing the person is wearing. In the summer when lighter clothing is being worn, the injuries were usually much less severe and generally resulted in minor abrasions, severe lacerations, and/or simple fractures to the lower extremities. However, when several layers of heavy winter clothing (coveralls, overalls, underwear) were being worn, the injuries were much more severe (compound fractures, multiple lacerations, contusions, or severe abrasions). Injuries were not always confined to the lower extremities and often resulted in a combination of injuries. All injuries resulting in fatalities or amputations occurred when the victim was wearing heavy clothing which did not immediately yield upon becoming entangled in the revolving shaft.

The first group, which encompasses a large number of items with similar characteristics, points out that a large number of accidents involve such protrusions as bolts and cotter pins which are used to attach the PTO to the machine or tractor. Many times such bolts and pins were not a part of the original equipment, but were a replacement, often left too long. In most instances, no effort had been made to cut off the extra length, and in a few the bolt had been bent over in the direction of rotation, forming a dangerous hook with no apparent thought given to safety.

It is evident from Table III that the spring loaded pin, commonly used as a method of attaching the PTO assembly to the tractor, is the single most serious point of entanglement of clothing. In fact, the spring-loaded pin is the largest single item upon which clothing became entangled, either on the X-washer, cotter pin, or the "push-button" portion of the device.

A highly significant fact illustrated by this table is the comparison of only four accidents credited to the smooth shaft as compared to 81 accidents involving a protrusion from the PTO assembly.

Clothing: The type of clothing and the manner in which it is being worn appears to be a very important injury factor in PTO accidents, and Table IV on the following page lists the kinds of clothing associated with the accidents.

The following discussion of work patterns contains examples of those found in this study. The first, illustrated in Figure 12, documents an unusual work pattern which increased the operator's hazard without any additional benefit to him.



Figure 12: The tractor and PTO driven elevator in the above picture were being used during the harvesting of eared corn. While using this equipment, the operator would mount the tractor platform from the left rear to start the tractor and engage the PTO. However, he dismounted from the right rear and stepped across the PTO to return to the elevator hopper. Such a pattern was particularly dangerous because of two conditions: (a) there was eared corn strewn on the ground around the tractor, and (b) the portion of the PTO which connects to the elevator was unshielded and the end of the bolt protruded from the shaft.

Another work pattern encountered in the investigations was the use of tractors designed to be mounted from the side. It was found that although an individual ordinarily used the designed means of mounting, there were occasions when he mounted the tractor platform from the rear. Such work patterns normally occurred



while using chore equipment in close quarters, such as the driveway of a double corn crib, cramped feeding areas, etc. This, coupled with the inherent dangers of the PTO shielding on tractors, as discussed in the "Machinery" section of this bulletin, can result in a work pattern which is dangerous.

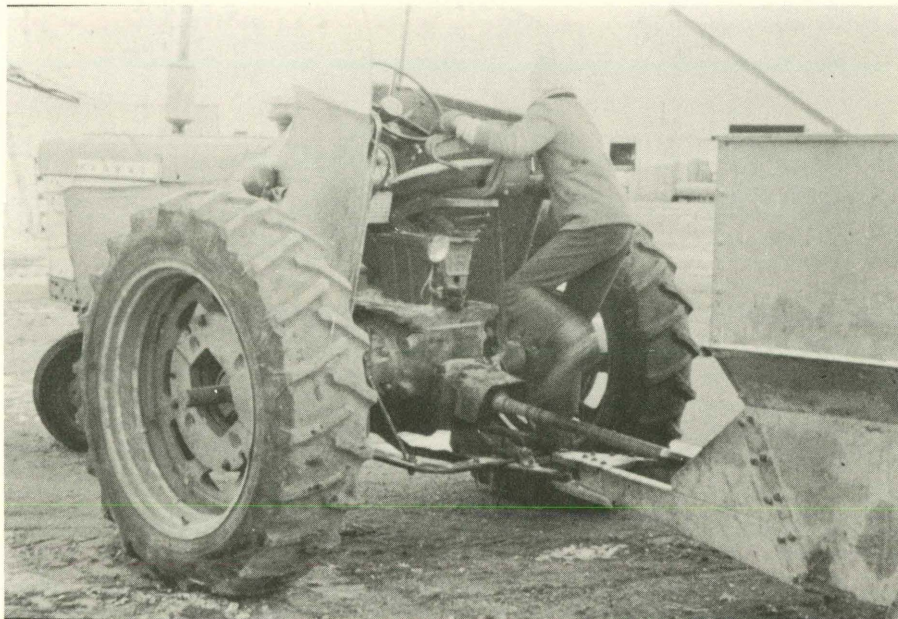


Figure 13: Operator jumping across PTO shaft to disengage power before the feeder ran over.



Figure 14: Operator mounting tractor to disengage PTO and move the equipment.

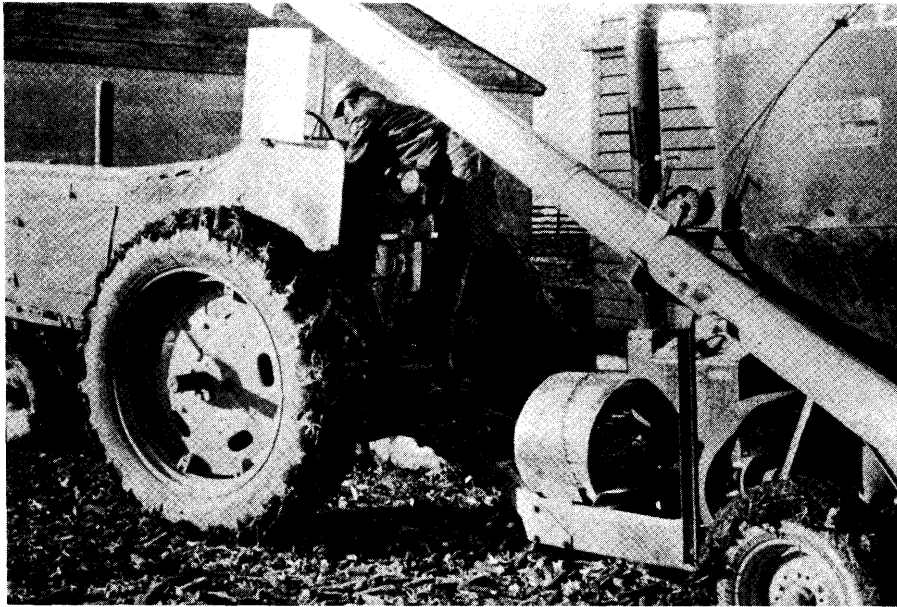


Figure 15: Operator adjusting throttle setting.

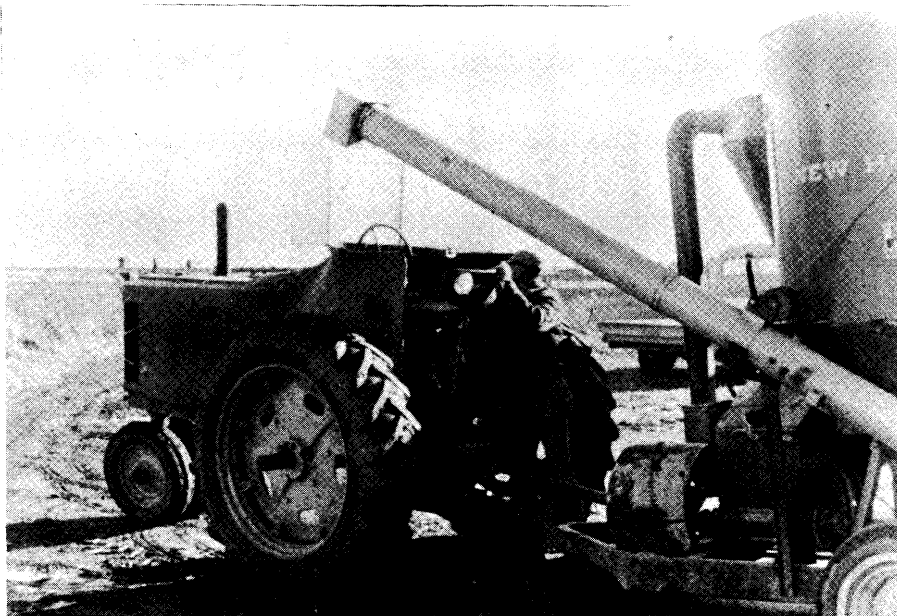


Figure 16: Operator disengaging PTO.

Figures 13, 14, 15, and 16 will illustrate the simple work patterns of adjusting tractor controls while using chore equipment. These pictures were taken during actual operation and while the PTO was running. In Figure 13, the operator is jumping across the PTO to disengage it before the feeder overflowed. In Figures 14, 15 and 16,



the operator was not hurried and these appeared to be typical of his normal pattern while using this equipment.

Note that he varies his procedure depending upon whether he is adjusting the throttle, disengaging the PTO, or disengaging the PTO and moving the equipment. In all of the cases the operator is working in close proximity to the PTO and with little apparent regard for the danger. How the work patterns of these individuals would vary if the shielding were removed is difficult to determine, but it can be seen in the preceding pictures that the front portion of the integral mounted shield was missing.

In some of the investigations, work patterns, which had become habits, were associated with mounting or dismounting a tractor and resulted in accidents which were difficult to believe. By way of illustration, a very energetic and successful 42 year old farm owner and operator was accustomed to using the master shield as a step for mounting the operator's platform from the rear of a late model tractor designed to be mounted from the side. He purchased a new tractor of the same model, but because of paint on the PTO shaft, he had difficulty connecting the elevator PTO, so he removed the master shield and failed to replace it. Later, when there was a malfunction with the elevator, he rushed to the rear of the tractor, attempted to mount in the usual manner, stepped on the revolving shaft and entangled his pant leg. Thus, failure to replace a shield cost him his right arm, plus numerous other injuries ultimately resulting in \$3,000.00 medical expense.

There are many other human factors which were frequently found in the accident investigations and recorded, but could not be analyzed. These included such things as

the victim's attitude toward safety and the condition of the machinery. Another factor was whether the victim was hurrying or distracted at the time, while still another was the pace at which the operator normally worked. One example is that of a victim who was very proud of the fact that he had a large farming operation and was "doing the work of two men." In other instances, the victim admitted to being very angry because of stoppage of the machine, while other victims would make no mention of such, even though there were strong indications that this was a factor.

## THE MACHINE IN THE ACCIDENT:

The machine is considered to include the tractor and the powered implement, and not just the PTO shaft, for it is the whole machine which dictates how it will be used. Such things as functional operation, minimum amounts of down time and malfunction, layout of the machine so as to promote safe working patterns, as well as the type and extent of shielding, are all important machine factors in PTO accidents.

Points of Entanglement: The first consideration involving machinery is the point of entanglement of clothing. As previously discussed, the principal points are the spring loaded pin, a grease fitting, a bolt, wire, or cotter key, all of which protrude from the periphery of the PTO shaft. Most often, entanglement occurred where the PTO was connected to the tractor or implement. Very few instances involved the universal joint or the bare shaft itself. Indications are that even when the clothing comes into direct contact with these two portions of the PTO shaft, it may not entangle immediately. It should also be pointed out that since the PTO turns in a clock-wise direction when running at the rear of a tractor, the cuff of an overall thus only becomes important when the individual is on the right side of the PTO. In this location, the protrusion will catch in the cuff and start to wrap. On the left side of the PTO the cuff would not be affected since the pin would be moving upward and is more apt to catch under the bottom of the pant leg.

Shielding: The first commonly used type of PTO shielding was the inverted trough shield, used exclusively until the early 1950's, and still used to some extent today. The reasons for the man's dislike for this shield have already been discussed. A major problem concerns the design life of these shields, which varied from flimsy

metal which will not stand up to heavy usage to those which are heavily constructed for durability. The operator may be at fault when shields are damaged. However, inasmuch as the shields are not necessary for the PTO to perform its operation, we cannot expect him to make immediate repairs or purchase replacement parts.

The inverted trough shield as best designed only offers protection to the operator from the top and sides of the PTO drive, and many shields offer only minimal side protection. Stationary drive lines covered with this type of shield are serious offenders regarding side protection. The problem of protection for the operator using the inverted trough shield is well illustrated in Figure 17.

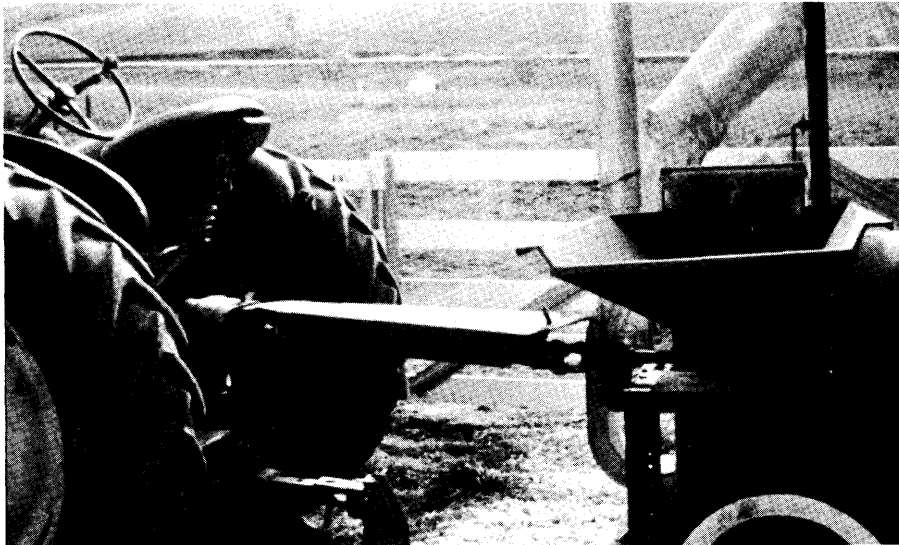


Figure 17: This heavily constructed inverted trough shield offers protection to the operator from the middle of the PTO, but no side protection where the PTO couples to the hammer mill or to the tractor. A cotter pin protrudes from the PTO shaft where it connects to the hammer mill and the first universal joint and there is a spring-loaded pin where it attaches to the tractor.

As mentioned earlier, one of the primary reasons for not using the U-shaped shield was because there was no shielding with the equipment when it was purchased.



In most cases this was used equipment, displayed without a shield, and the purchaser did not inquire about a shield at the time of the sale. In some cases when he did inquire, shielding was not presently available and he continued to operate the machine without it. Another factor is that with used equipment, it may not seem economical to the operator to purchase new shielding.

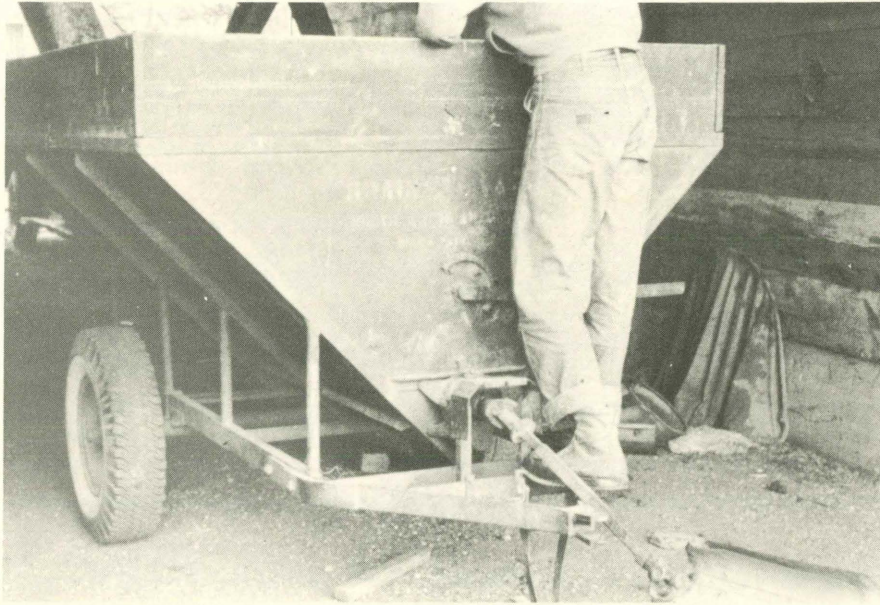


Figure 18: Victim standing on drawbar as at the time of the accident.

Figure 18 shows an auger wagon which was purchased second-hand by an accident victim and illustrates the economic philosophy which produced an accident. Approximately one month after the purchase of this wagon the operator became entangled in the PTO as he was standing on the drawbar to observe the contents of the wagon. He had asked about the cost of purchasing an integral mounted shield for the PTO and was informed that such a shield necessitated the purchase of a new PTO shaft, and this would represent a considerable portion of the total investment. However,

after the accident he made the inverted trough shield shown in Figure 19, and has since made a similar shield for a recently purchased used mower.

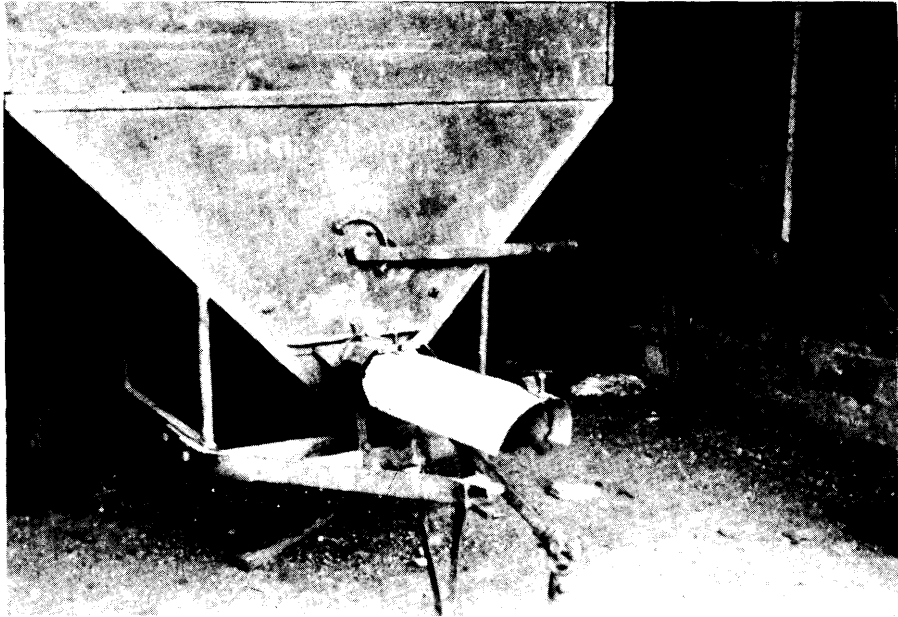


Figure 19: Inverted trough shield constructed by the victim after the accident.

A major problem in shielding of PTO equipment is the tractor's master shield. In half of the accidents in which there was no PTO shielding in place, the accident resulted because the master shield was missing. These accidents can be grouped into four classes of tractors:

1. Older tractors which are not normally used for PTO work and for which the master shield has been unserviceable for some time. They are used temporarily during combining small grains because some other machine, like a cultivator, is mounted on the tractor normally used for the PTO operations and dismantling it means extra labor and time.



2. Very old tractors used primarily as an auxiliary engine since the tractor has little resale value.
3. Early model tractors (which were mounted by the operator from in front of the rear wheels), often sold without master shields or sold with the master shield as an optional piece of equipment.
4. Tractors which are used with mounted equipment such as cultivators, plows, cornpickers, etc., which require removal of the tractor's master shield when mounted. However, in most of these cases, the master shield is in good condition, but the operator had failed to replace it after removal.

Among the PTO accidents investigated, 17 cases involved equipment with an integral mounted shield, but lacking a master shield on the tractor. Further, the accidents primarily involved chore equipment which is used regularly throughout the year - but for short periods of time. Familiarity with the use of this equipment and inconvenience in replacing the master shield unquestionably contributed to the accident picture.

The fact that a tractor is mounted from the front by design does not mean that the size, shape, durability and need for the master shield is lessened.

Not only do farmers occasionally dismount from the rear, as we discussed in the "Man" section of the bulletin, but they also continue to use the tractor's drawbar as a place to ride. Most tractors which are mounted from the front seldom have drawbar supports where a person can stand or mount from the rear without bringing his legs into close proximity to the PTO. Thus, a more adequate, rather than a less

adequate, master shield is necessary on the tractor.

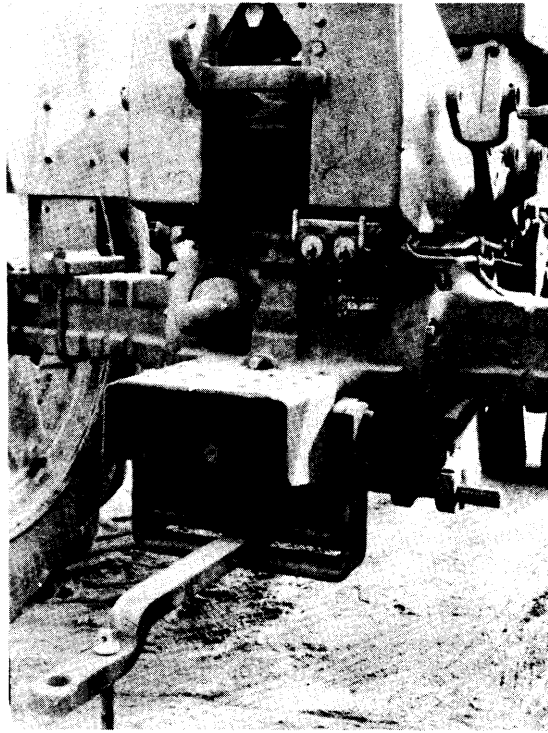


Figure 20: Rear view of front-mounted tractor. The only plausible place for mounting from the rear or riding as a passenger is the drawbar or master shield.

Machinery problems of special interest are those pieces of equipment which mount directly on the PTO shaft, requiring the removal of the master shield, or those machines, which, for clearance purposes also require its removal; these machines create designed-in hazards to the operator, for as mentioned earlier, if the master shield is removed by necessity, there is reason to believe that it may not be replaced at the first opportunity if replaced at all.

Integral Mounted Shields: There is little doubt but that integral mounted shields are an improvement in safety shielding. The primary reason for this is not because it completely shields the equipment, but rather that it is a shield which the farmer

uses and readily accepts. He is pleased with it because he does not have to bother putting it on and off, and there is little maintenance required. Also, it would appear to give minimal restriction to use of his equipment. However, with all of its advantages, it cannot be considered perfect. One problem encountered with this shielding is that its bearing supports wear out. Although only one accident resulted directly because of a bearing failure, it was a contributing factor in several other accidents. In these instances the operator complained that replacement bearings had been used, but would no longer stay in place - thus the shield was no longer used. The primary reason appeared to be that some time had elapsed between the time that the bearing wore out and replacement was made, allowing the bearing slot to become rusted, causing severe rapid wear to the new nylon bearing.

The integral mounted shield, however, does not shield the area where the PTO connects to the tractor or implement, which appears to be the most dangerous portion of this device.

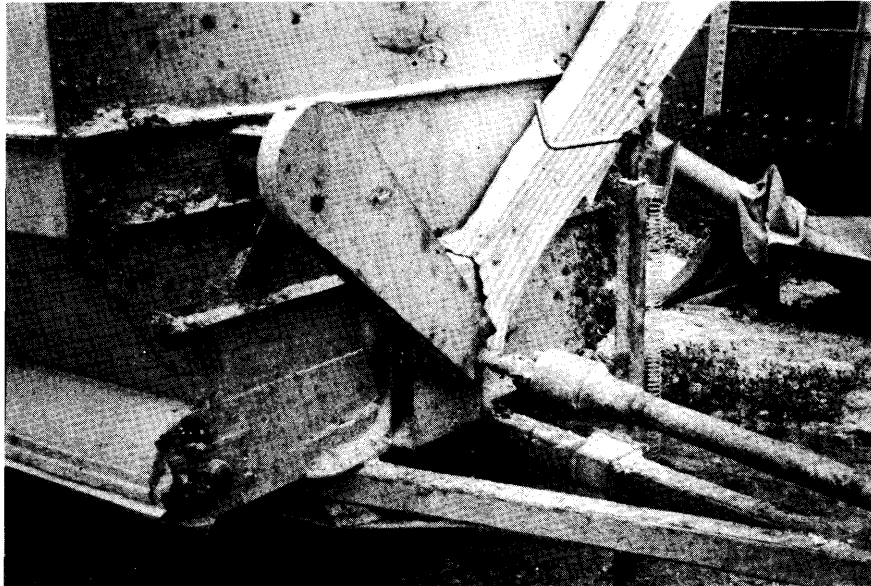


Figure 21: Auger wagon with integral mounted shield but no stub shield.

Stub shields either inadequate in design or lacking in manufacture were a major factor in accident causation in the category "all manufacturer's recommended shields in place," mentioned earlier. In most instances, no shield was provided by design (see Fig. 21); however, where they were provided they were often inadequate for operator protection. Inadequate shields are usually too small, easily moved by contact with the operator's person or clothing when hinged, and constructed of flimsy material.

As the study progressed, it was found that many of the former shielding problems (older types of shields) had been eliminated. However, the introduction of new equipment presented a new series of problems. Today, the supposedly best combination of PTO shielding (tractor master shield, integral mounted shield, and stub shield) still permits accidents. Of particular concern with this improved shielding is the fact that the operator's leg may still slip between the master shield and the integral mounted shield. Although these accidents have not been frequent, they have been serious. Figure 22 shows the area in which the leg of a man can easily slip between the master shield and integral mounted shield. The stub end of the PTO has a similar problem.

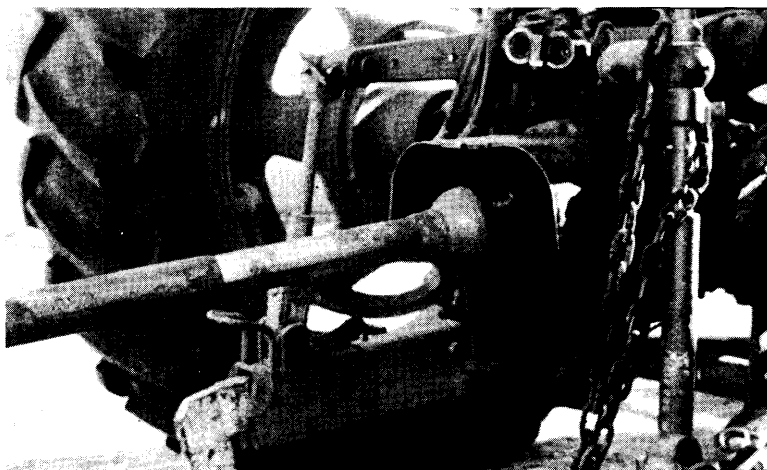


Figure 22: View of open area between integral mounted shield and tractor master shield.

The design of a machine dictates the work pattern of the user. A good example of this principle is the type of accident associated with the use of the auger-wagon.

The Y-frame at the front of the wagon, above which a PTO operates, (see Fig. 21) has provided a convenient platform for the operator to stand on as he visually observes the unloading process. This frame, which is obviously acceptable, must of consequence be designed to protect him from the PTO drive.

## THE ENVIRONMENT IN THE ACCIDENT:

Environmental factors of primary concern are those which influence man; however, effects on operation of the machine are also of importance. The most common and easiest factors to evaluate are those of climatic origin manifested by rain, mud, snow, ice, frost, and wind. Some of the less obvious and more difficult to evaluate are such things as cold, heat, noise, and vibration. Even the physical and social aspects associated with farming are environmental problems. In a broad sense, the location on the farm or farmstead, or the nature of working on the farm itself can be considered as an environmental factor in the accident.

Slippery conditions underfoot, such as mud, snow, ice, and frost, were the most commonly reported environmental factors in an accident, causing the operator to lose his balance while mounting or dismounting the tractor or equipment. They were most commonly associated with chore-equipment and of particular significance when the equipment was being used in the livestock lot. Figures 23, 24, and 25 illustrate some environmental conditions on the farm.

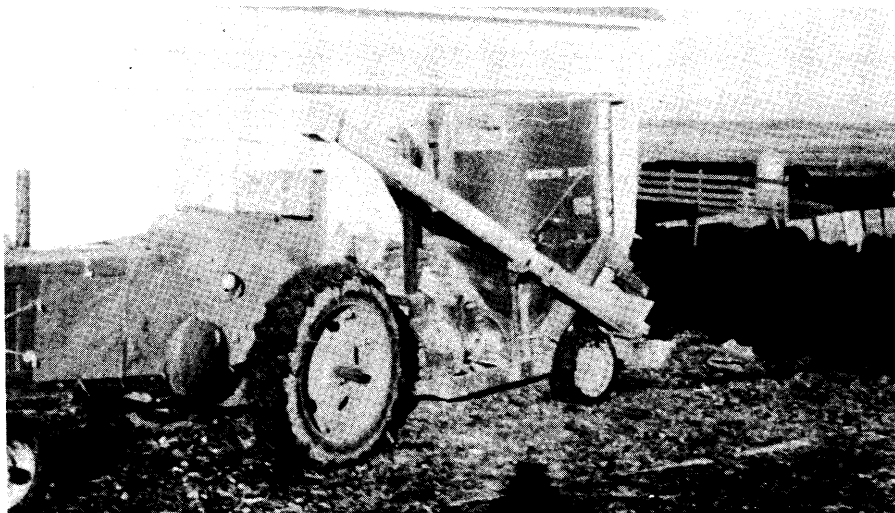


Figure 23: A grinder-mixer being used in the feed lot under muddy conditions with loose corn cobs underfoot.



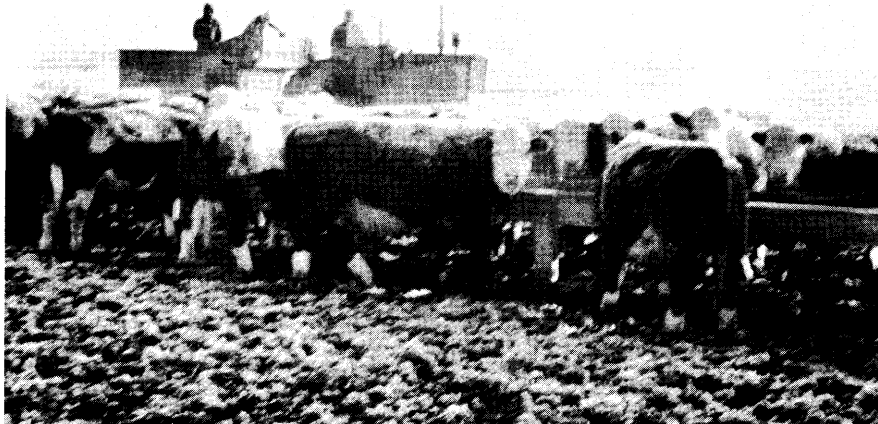


Figure 24: A feed wagon being used on a cold winter morning with heavy frost about, making mounting and dismounting of equipment hazardous.



Figure 25: A grinder being used on hard ground with eared corn underfoot.

Cold or hot weather, high noise levels, and vibration are all conditions which can reduce an operator's capabilities. Although it is reasonable to assume that such factors were involved in some of the accidents, no quantitative evaluation was made

or can be implied from the study. However, the implications can be seen in studies reported by other industries, and in such articles as can be found in the Journal of Aero-Space Medicine.

Using the broadened sense of "environment," one can point out some of the problems associated with the location of the operation being performed on the farm or farmstead. For instance, because the man is working in the field away from the farmstead, where repair parts are available, he will substitute with materials at hand, and, for example, use a bolt for a shear pin in the PTO. Such substitution, changing a reasonably safe attachment to a highly dangerous device, may remain unchanged until it becomes inoperative.

The layout of the farmstead and the equipment may be considered special environments in which the operator works. For instance, because of the layout of the buildings, an operator may be forced to operate a machine (whether he likes it or not) in a limited space. He may have to operate grinders and feed wagons in narrow driveways of corn cribs which were designed before this machine was put into use, thus forcing the man to change his work patterns. Under such conditions, in a narrow corn crib, it may be necessary for the operator to dismount a tractor from the rear alongside the PTO whether he wishes to or not, because he cannot pass between the outside of the tractor wheels and the wall.

In a very special sense, the farmstead presents unique environmental hazards to children. On most farmsteads, the home and the father's place of business are the same, creating the additional problem of children being exposed to dangerous equipment constantly. This fact was encountered in several investigations when youngsters

would climb on farm machinery without the father's knowledge and receive a PTO injury.

## EPIDEMIOLOGICAL CASE STUDY:

Considerable space in this bulletin has been devoted to describing the man-machine-environment relationships of an injury resulting from an accident. The following epidemiological case study discussion of a particular accident illustrates the importance of these segments of an accident if the ultimate cause is to be ascertained and logical corrective measures determined.

### Case: PTO-102

Man: Mr. Edward T., aged 42 years, vice president and general manager of a manufacturing concern with head offices in Iowa, was the victim of a PTO accident. He was not raised on a farm, but as a boy worked summers on an uncle's farm. He graduated in agricultural business from a mid-western university and worked mainly in sales. While working at a branch plant, he rented a farm and fed beef cattle. Some three and a half years ago, he had moved to Iowa, and a year ago had purchased a 320-acre timber and pasture land farm. He built a new home on the farm and spent most of his spare time working the farm, putting in fences and making general improvements.

On the day of the accident he came home from the office at 11:00 a.m. to help the hired man dig post holes through the lunch hour. They were trying to set a half-mile of fence posts that day because the following day eight or nine of Mr. T.'s friends were coming to help put on the wire. When Mr. T. arrived, the hired man started setting posts in the dug holes, while Mr. T. took over operating the post hole digger. Mr. T. was experienced in the use of the post hole digger as he had used it during the summer and fall while making fence around the farmstead.

Machinery: The post hole digger was mounted on a two-plow tractor which was over fifteen years old. The post hole digger, with a nine-inch auger, was purchased new recently and had no shielding. However, the tractor master shield was in place at the time of the accident.

In operation, the post hole digger is raised by means of two hydraulic cylinders positioned one on either side of the drawbar, but only the weight of the auger causes it to penetrate the ground. Normally, no difficulty is encountered in getting the auger to start boring into the ground. However, it is occasionally necessary to dismount from the tractor and add the force of the operator's weight to it (pressing down on the gear box) before it will penetrate hard or frozen spots in the ground. Because of the way this equipment is mounted on the tractor, it affects the man's use of the equipment by making it difficult for him to dismount in his normal manner (using the tractor's axle and drawbar as steps). With the equipment mounted it is still possible for him to use the draw bar as a step but he must be more cautious and take more time in doing so. The mechanical separation of operator and PTO drive afforded by the auger support arms is only on the side with no top protection in case of a fall.

Environment: This accident occurred on December 6, 1963, and the ground had frozen the previous night. At the time of the accident, approximately 11:00 a.m., the sun was shining and the ground had started to thaw, making it muddy and "greasy" on top. This effect was heightened by the fact that the victim and helper were working on a side hill where a bulldozer had recently scraped brush from the area, exposing clay soil.

Circumstances of the Accident: At the operating site the victim dug four or five postholes without any difficulty. However, just prior to the time of the accident he came to a place where the bulldozers had scraped off the topsoil and the auger would not penetrate the underlying hard clay. He then dismounted from the left rear of the tractor by stepping on the axle before jumping to the ground. Because of the slippery footing, he started to fall and presumably reached for the frame of the post hole digger to regain his balance. His coat sleeve caught on the gear housing end of the PTO, pulling him up onto the A-frame of the posthole digger and throwing him about it several times before stalling the tractor. The hired man who was operating a bulldozer nearby, freed him from the PTO and rushed him to the hospital.

At time of accident, the victim was wearing a pair of bib overalls, shirt, sweat-shirt, and overall jacket. When the tractor stalled, practically all of the clothing had been torn off of his body and he was lying partially on the ground under the post-hole digger clad only in his rubber boots. The left arm had been nearly severed during the removal of the clothing and additionally, the scrotal covering was absent from the testes and the skin gone from the shaft of the penis.

Medical Information: He arrived at the hospital emergency room approximately 15 minutes after the accident and emergency surgery was performed to complete the amputation of his left arm, which was only held in place by a few tendons and nerves. His loss of blood had been low considering the extent of injuries received, but he was immediately given three additional pints to help replenish his blood supply and reduce primary shock. That night he was listed by the hospital as being in serious condition. The following morning, he was in surgery again for six and a half hours.



Recovery was uneventful and he was released on December 23, sixteen days after the accident, returning to work on January 6, just a month after the accident. At the time of return to work, all operative sites had healed, but medication was still being given for the severe pain in the left shoulder caused by the severed nerves.

The sustained injuries included:

1. Amputation of the left arm just below the shoulder, termed by Dr. A. a "torsional amputation."  
Fracture of the left humerus four inches below the shoulder.
2. Tearing of portion of the scrotal sac. The testes had not been injured, and after trimming some of the dead skin, the remaining portion was sutured back into place.
3. Fracture of three left and two right ribs.
4. Extensive lacerations of the lower left leg and a large laceration under the right arm.
5. Severe bruising over the entire body and some skin abrasions on legs.
6. Ruptured blood vessels in the right eye, causing a cloudy spot on his right eye which is slowly decreasing in size and is hoped will disappear completely.

Final Analysis: The man was obviously operating under pressure of a deadline, for he jumped from the tractor rather than stepping down. The footing was poor and he was working on a side hill. In falling, his natural tendency was to catch himself, and in reaching for the nearest support, he came in contact with the PTO drive.

Upon examination of the PTO and through discussion with the victim and his hired

man, it was determined that he had become entangled on the pin used to attach the PTO to the auger gear box. This pin protrudes one-half inch from the surface of the PTO attaching yoke.

A mechanical barrier is provided the PTO drive on either side by the support arms and an integral mounted shield could have been secured if he had been willing to wait on order rather than purchasing the equipment available as a floor model. The fact that this equipment did not have the integral mounted shield was of little consequence, for the lack of a stub shield provided the opportunity for the man to come into contact with the PTO drive.

Figure 26 shows the equipment following alterations made following the accident.

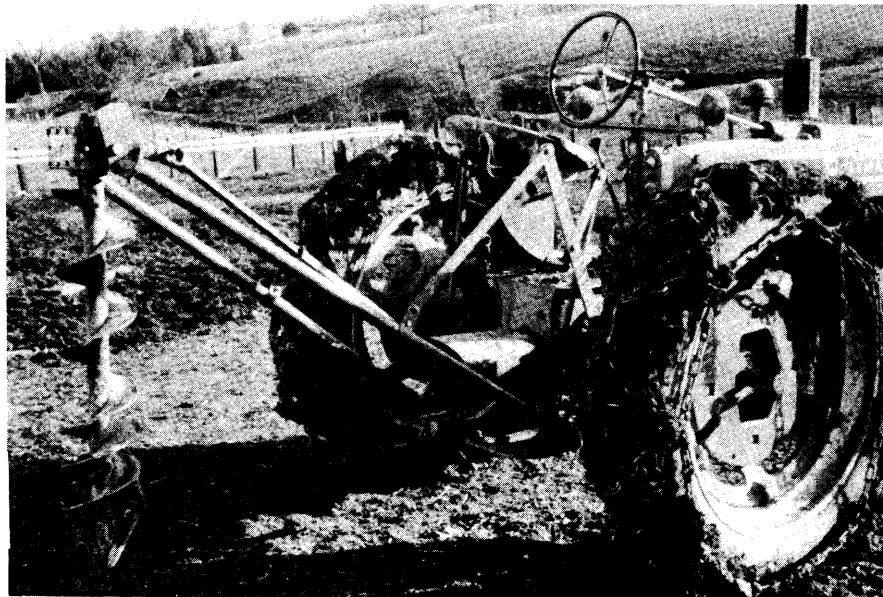


Figure 26: Edward T. tractor and post hole digger.

The protruding pin has been cut flush with the drive yoke and an angle-iron welded to the top of the auger to provide a safer means of forcing the auger into the ground, as well as providing mechanical support for the operator when working near it on slippery ground.

## IMPLICATIONS FOR DESIGN CHANGE AND SAFETY EDUCATION

Our traditional preventive action for the safety of the agricultural worker has been an attempt to manipulate his behavioral patterns through safety education. He has been informed of the problems of machine use, the effect of environmental factors, and told of his unreliable behavior patterns.

The findings of this study point out the great variety of circumstances surrounding an injury and lead one to the conclusion that, of the man-machine-environment factors, the one most easily amenable to change is the machine. It is obvious that the worker must of necessity work under a wide variety of environmental conditions, and will go about his tasks in whatever way he thinks best for a given situation. Consequently, the worker must then be provided with the security that he should provide for himself, for his behavior pattern is not predictable.

New methods and increasing numbers of machines are being developed every day to assist the farmer in carrying out his work, and in a great many instances, these machines are PTO operated; thus the following points are germane to future PTO design.

1. All protrusions on the attaching collars should be eliminated.
2. A master shield for the tractor power take-off should be developed which offers greater protection to the operator and does not require removal.
3. Improved stub shielding is needed on the driven implement.
4. The design life of the shield should be commensurate with the

projected life of the machine.

5. The development of an adaptable PTO shield fabrication kit is needed for equipment with outdated shielding.
6. Shielding for the unexpected should be the rule rather than the exception, for accidents are not as a rule the result of normal situations.

The chief value of this study is the attempt to define the injury problem associated with the PTO drive. Its ultimate value to society now rests with the designer who applies this new knowledge toward creating a safer PTO drive than now exists.

## SUMMARY

The purpose of this research project was to define more accurately the injury problem associated with the farmer's use of PTO (power take-off) equipment and to develop information which would be helpful in designing safer equipment.

The following pertinent observations are made as the result of epidemiological investigations.

1. The sequence of events leading to an injury was contact with the PTO, entanglement of clothing, and the subsequent wrapping of clothing about the PTO drive line.
2. PTO accidents range in severity from no injury to death.
3. The amount and type of clothing worn by the victim also greatly affected the severity of the injuries. In summer, when light clothing was worn, it was more typical for the clothing to be ripped from the victim and injuries to be of the nature of lacerations and abrasions. In winter, with heavier clothing, it was found that injuries more frequently involved fractures and amputations, and occasionally were fatal, because heavier clothing tears less readily.
4. The danger areas of the PTO were identified and the spring-loaded pin or equivalent found to be the greatest offender in entanglement of clothing.

5. Unusual events occurring while the PTO is in use (plugging of the machine or a malfunction) cause even the cautious operator to follow unsafe practices.
6. Shielding, and in particular, the inverted trough type, does not have as long a design life as the PTO. It is often discarded and seldom replaced.
7. Environmental factors of weather and visibility contribute to many accidents.
8. Rescue of the injured person for medical treatment is a critical problem. Early location of the injured and removal from the machine can make the difference between life and death.
9. The above findings indicate the necessity for changes in design of the PTO and for greater use of safety education.

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November 12, 1960, pp. 106-112.
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Hindman, L.                Vehicle Accidents, Bulletin #7, Institute of  
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3. Knapp, L. W., Jr.           The Man-Machine Relationship in Tractor  
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APPENDIX 1

Accident Reporting Card

←-- (tuck-in tab for slot  
at bottom)

POWER TAKE-OFF ACCIDENT  
STUDY

Date \_\_\_\_\_

To Institute of Agricultural Medicine:

\_\_\_\_\_  
(name) (address)  
who lives on a farm in \_\_\_\_\_  
(county) (tel. no.)

was involved in a power take-off or revolving shaft accident.

Result: (check)

\_\_\_\_ not injured  
\_\_\_\_ treated by doctor  
\_\_\_\_ hospitalized

The accident involved:

\_\_\_\_ tractor  
\_\_\_\_ combine  
\_\_\_\_ picker  
\_\_\_\_ grain elevator  
\_\_\_\_ other \_\_\_\_\_

\_\_\_\_\_  
(signature)

Remarks:

\_\_\_\_\_  
To close, staple or tuck in tab

APPENDIX 2

PTO ACCIDENT INVESTIGATION (Victim Interview and Hospital Record)

Wilbur P. PTO-18

Mr. P. became entangled in the PTO of a hammer mill while grinding feed with the help of the hired man. The accident occurred about 9:00 a.m. April 12. There was some snow remaining on the ground and the overnight temperatures were below freezing. The sun was shining and the ground was beginning to thaw on top. The hired man was scooping eared corn from an adjacent corn crib into the mill and Mr. P. was on the pick-up truck, leveling off the ground corn. He noticed that the screen in the grinder was working out. He hurriedly climbed down from the pick-up truck and rushed to disengage the tractor PTO to prevent the hammers from striking the screen and causing damage to the machine and possible injury to the hired man.

He approached the tractor from the left rear side and stepped upon the left side of the tractor drawbar with his right foot. As he stepped upon the drawbar, his clothing became entangled in the PTO. He held onto the tractor seat and fender as it caught his clothing and tore it from his body. During this time, it felt as if the PTO was just "chewing the coverall", he stated, and he had no feeling of pain. He did not realize that he was injured until he stepped upon the ground with his right leg and found that it would not support him. When he looked at his leg, he saw a bone protruding from the flesh. He later learned that only the flesh and muscle on the back of the leg had been holding his lower leg and foot. The hired man and Mrs. P. loaded him into the family car and took him to the county hospital. During this time Mrs. P. supported the foot and attempted to stop the bleeding. According to Mr. P., he was very sure that the leg would be amputated upon arrival at the hospital.

At the time of the accident, Mr. P. was wearing a pair of bib overalls and a pair of coveralls with the pant legs of both overalls and coveralls tucked into insulated rubber boots, with leather shoe laces. It is believed that the spring-loaded pin of the PTO caught the right pant leg of the coveralls as he stepped upon the draw bar. The PTO was about knee height of the operator above the tractor drawbar. The lower three-fourths of the right coverall and overall pant leg and the right insulated boot were torn off. The top half of the insulated boot was found wrapped around the PTO, between the layer of coveralls, which was next to the PTO shaft, and the layer of overalls, which apparently was the last thing to wrap around the PTO. The rest of the boot was found near the corn crib. Mr. P. believes that the tough leather laces on the insulated boots contributed greatly to the seriousness of the injury.

At the time of the accident, the hammer mill had an integral mounted shield, but the tractor's master shield was missing. Mr. P. explained that the reason for the shield's absence was the result of a property damage accident to the tractor during the past winter. The hired man had left the tractor and the attached loaded manure spreader in the hog lot. The tractor's brakes had not been set, and it is believed that the hogs rubbing on the tires caused the tractor to start coasting down a hill. The tractor and spreader went through a fence and finally stopped when they struck a tree. This had resulted in extensive damage to the tractor, including damage to the PTO shield. The tractor had been repaired since the time of this accident, but Mr. P. had failed to replace the damaged shield. He stated that he was aware of the danger of not using the shield and had normally been very cautious when mounting the tractor. However, at the time of the accident, he had been in a hurry and had given no thought

to the missing shield. Also, because of the thawing and muddy conditions at the time, it is possible that he slipped as he stepped on the drawbar, causing him to come into contact with the PTO. However, Mr. P. cannot recall if he slipped, since it all seemed to happen so fast.

After his accident, friends have told him they were not accustomed to using the master shield on a tractor, but have since purchased shields for their tractors. He also related that a neighbor boy, about 8 or 10 years of age, had his clothing torn off in a PTO at about the same time as his accident. When the boy's father was combining oats for Mr. P. this summer, he was still using an unshielded PTO. Upon mentioning this to the neighbor, he just laughed and shrugged it off.

A summary of the county hospital's medical record for Mr. P. :

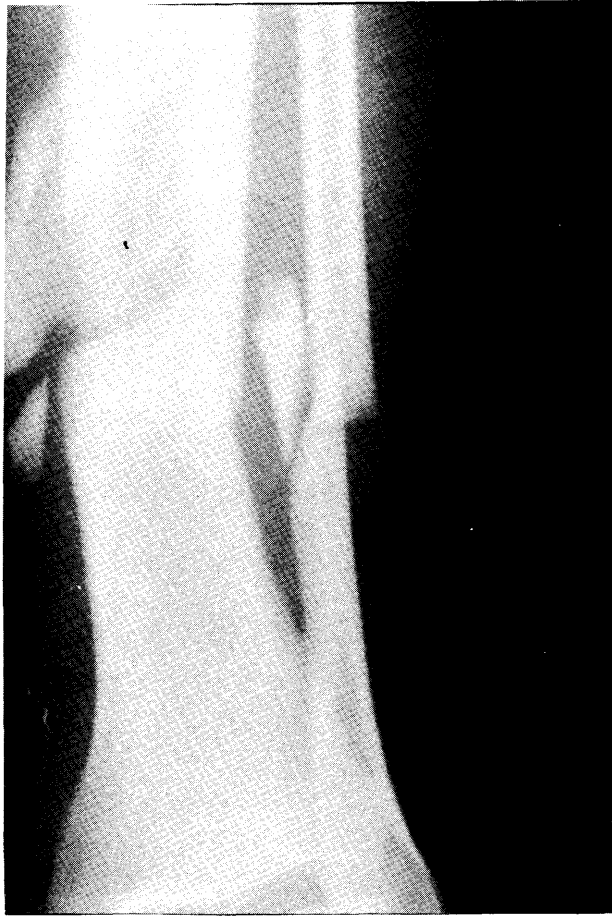
Mr. P. was admitted to the hospital on the morning of April 2, and released on April 22. According to the medical records, he was admitted with a laceration which started about three or four inches above the right ankle on the inside of the leg and ran diagonally up across the front of the leg. X-rays of the right fibula and tibia show a compound comminuted fracture involving the distal thirds of both bones. A fragment approximately two inches long of the tibia was rotated 90° with respect to the major fragments. In addition to the fractures of the fibula and tibia, there is a long spiral fracture of the tibia near the knee (not shown in the enclosed X-rays). During the time when he was first hospitalized there was great concern about the possibility of infection in the wound. Because of the size and nature of the wound, there was a large accumulation of dirt acquired at the scene of the accident. In addition, because of the small amount of flesh holding the foot, there was no support



and the movement of the foot in transportation tended to imbed the dirt in the flesh and bone, making cleaning difficult. However, no serious infection evolved. The original cast was removed several times for further open and closed reductions of the fractures. Also, metallic pins were inserted through the bones to help straighten and orient the bones. He was readmitted on May 29 with what was first believed to be pleurisy, but he was later told that it was a blood clot in his lung. Again on June 18 he was admitted because of a blood clot in his left leg. Again hospitalized in January, he underwent a bone-grafting operation. The following spring, a year after his accident, he was still wearing his cast, but was able to be about and did a limited amount of field work with the tractor. Finally, in September, almost 18 months after the accident, the last cast had been removed and he was able to get around for the first time without the aid of crutches.



X-ray #1: Fracture when admitted to hospital



X-ray #2: Fracture after initial  
reduction



SEGMENT OF TAPE RECORDED INTERVIEW (PTO accident investigation)  
Leland R. PTO-47

Mr. R. This happened while I was feeding my cattle out in the feed lot. Normally I use a standard tread tractor of a 3 plow size which had a PTO. For some reason, the live power take-off was giving trouble, so I had out it in the shed and I was going to use this other tractor which was equipped the same way with live power take-off. This tractor had been used with the mounted cornpicker and it had a shield over the PTO but the shield had been bent when a PTO knuckle on the mounted cornpicker had broken and swung around - so we had taken it off as it was not necessary to have it on when we had the picker on.

Well, just using this tractor for a day or two, I didn't think much about it --- I knew the shield should be on and I always used tractors which had them on. It was my oversight because when I walked around the right rear and stepped up on the tractor, there wasn't that shield there to protect me when I stepped up there even though the PTO shaft was properly shielded and everything --- it has one of those round, revolving shields and there was just a couple inches there where the spring-loaded pin that holds it onto the PTO caught my boot and did the damage.

Interviewer: You were stepping up from the right side of the tractor?

Mr. R. That's right, stepping over. Of course, it was the spring-loaded pin, the PTO shaft is fully protected -- I can sit on it when it's running -- it wouldn't hurt you. It offers full protection. Often times when you are feeding cattle, you have to let the thing run to finish cleaning out because it will freeze up between one feeding and the next. That's the reason the thing was running. I know it isn't normal procedure to have a PTO outfit running when you are working, but on the other hand, a grinder or a bunk-feeding wagon or something like that, you can hardly help it.

Interviewer: What happened after you first felt the PTO catch your clothing-- what did you do?

Mr. R. The only thing I could do -- it happened so suddenly -- I hung onto

the steering wheel to try and maintain my grip as long as possible and keep my whole body from being drawn into it. I suffered some bruises on my chest and arm where I hung onto the steering wheel and had draped my chest over the seat of the tractor. That kept me from being any more drawn into the PTO. The same time, the pull became great enough that the tractor (just idling) died. The same time, the bones were breaking. I heard the bones breaking in my leg as the tractor died. Of course, it all happened so suddenly there wasn't anything you could do about it -- all you could do was witness it. You knew what was happening and you were powerless to do anything.

**Interviewer:** What did you do, then, after the tractor died? How did you get out?

**Mr. R.** The first thing I did was to holler for help. While I was hollering for help, I was looking for something I could cut with -- I had a knife that was very dull -- I was finally able to cut enough cloth to free my leg -- I had a scoop shovel hanging over the wagon, and I thought I could use it as a crutch and get to the house. At that time -- it was rather chilly that morning -- I would say about 5° above -- in cutting myself out of the shaft, I was becoming fairly exhausted. The scoop shovel proved to be inadequate for a crutch and I went to the ground, face down. As I went down, I recognized somebody coming over the fence, running to my assistance. It was my neighbor. When he got there I told him to go up to the house and to tell my wife that I had been hurt. All this time, I was conscious--I knew what was going on--I had a billfold in my pocket with considerable cash--I told this man to see that somebody got my billfold, and not to lose it--I told the man what chores were done and what needed to be done--how much to feed them. And even though I was under terrible shock and strain, it was hard to maintain myself, it didn't happen soon. When I got to thinking about the fact that an ambulance should be here, I heard the siren and I was conscious all the time until they put me under to go ahead and set my leg.

**Interviewer:** How did this neighbor happen by? Did he hear you?

**Mr. R.** He lives half a mile away, west up the road, and I hollered as loud as I could. "Somebody please help, Help! Somebody." And I remember the last time I hollered and I layed down there and at that time this neighbor showed up and he had heard my cry -- but he had also heard me in the morning calling the cattle. The



wind was in the right direction-- he for some reason had gone into the house and something bothered him and he came back out and decided that something was wrong, so he drove down and I am sure that's what saved my life because I could have died right there.

Interviewer: Did it tear off all of your clothing?

Mr. R. Just as the tractor died my suspenders broke and everything went down, all right at that one time. It's hard to say what would have happened if the tractor had been going at a good speed.

Interviewer: What were you wearing?

Mr. R. I was wearing just a slip-on boot that had no fabric in it. It was a pair of rubber boots and I wore a pair of overalls and a dacron insulated underwear.

Interviewer: You think the pin caught the top of the boot?

Mr. R. It caught the side of the leg and started winding up. It just started twisting and grinding everything together. A piece of iron doesn't have any feeling. I've worked around machinery an awful lot and am well aware of how brutal it can be. Frankly, I'm very thankful I'm here.

Interviewer: What did it do to you, as far as injuries. You mentioned that you had bruises on your chest and arm.

Mr. R. It completely broke the bone in my leg and when I looked down from the tractor when it died, I saw that one of the main bones in my leg from the ankle up was sticking out completely stark of flesh--the flesh was badly mutilated, especially on the one side of the leg. To get a good substantial stump to make a satisfactory artificial leg installation, the doctors thought it best to amputate it just above the knee -- that way I am told you'll get a better stump than if you try to get by with a partial below the knee.

Interviewer: You mentioned to me that they had thought about setting the leg...

Mr. R. They did set the leg and I went along for three or four days-- this happened on a Monday and it was the next Thursday they amputated. It never has been the policy of these doctors to amputate arbitrarily--they try to save as much as they can, and

I have seen some very hopeless cases where they turned around and kept a man's fingers so that he could use them when they were mangled.

They finally had to amputate because it was impossible to get a complete sanitary job of cleaning out the barnyard dirt from where the accident occurred. They tried to disinfect and sterilize -- they were hoping that modern antibiotics and disinfectants would be successful, but I woke up one day and you could smell that barnyard right here in the bed, and you knew right then they had not accomplished it, and so before infection could spread up your leg and maybe take my life, they went ahead and amputated, for which I'm very thankful.

Interviewer: You mentioned earlier that shortly after the accident, several of the neighbors talked to you about putting shields on their equipment.

Mr. R. The comments made to me afterwards when some of the people came up to the hospital said, "Why you've got some neighbors that went right home and put shields on their tractors !" I know of one neighbor in particular who has not used any type of shield for years. Of course, he doesn't use the tractor much for PTO work, but if he did--his would have been running the grinder-- he would have had the same protection identically as what I had-- he would be minus the same amount of protection that mine was-- that one little stub shield -- they protect you from the spring-loaded pin that holds the knuckle onto the PTO shaft, and that's what caught my boot and started twisting everything up.

APPENDIX 4

PTO ACCIDENT ANALYSIS FORM:

Institute of Agricultural Medicine, University of Iowa, Iowa City

PTO Accident Analysis Form

Accident No. \_\_\_\_\_ Investigation date \_\_\_\_\_

County \_\_\_\_\_ Date \_\_\_\_\_ Hour \_\_\_\_\_ A.M. \_\_\_\_\_ P.M. \_\_\_\_\_

Location \_\_\_\_\_ Miles \_\_\_\_\_ N \_\_\_\_\_ S \_\_\_\_\_ E \_\_\_\_\_ W \_\_\_\_\_ of

\_\_\_\_\_, Iowa.

Reporting Source \_\_\_\_\_

OPERATOR INFORMATION

Name \_\_\_\_\_ Address \_\_\_\_\_

Age \_\_\_\_\_ Male \_\_\_\_\_ Female \_\_\_\_\_

Farmer \_\_\_\_\_ Hired Man \_\_\_\_\_ Retired Farmer \_\_\_\_\_ Student \_\_\_\_\_ Other \_\_\_\_\_

Clothing (amount, kind, condition) being worn at time of accident \_\_\_\_\_

PTO Operating Experience

Frequency and Time of Use of Machine Involved \_\_\_\_\_  
( Ex:Elevator - once weekly, 2 hours)

Frequency and Time of Use on Other PTO Machines: List

- 1. \_\_\_\_\_ 5. \_\_\_\_\_
- 2. \_\_\_\_\_ 6. \_\_\_\_\_
- 3. \_\_\_\_\_ 7. \_\_\_\_\_
- 4. \_\_\_\_\_ 8. \_\_\_\_\_



Appendix 4, Accident Analysis Form, continued:

Activity at Time of Injury:

1. Standing on ground near equipment \_\_\_\_\_
2. Mounting \_\_\_\_\_ Dismounting \_\_\_\_\_ the tractor
3. Mounting \_\_\_\_\_ Dismounting \_\_\_\_\_ the PTO-operated  
driven equipment
4. Other \_\_\_\_\_

If mounting or dismounting tractor, or equipment, specify position in relation to the PTO shaft when facing in the direction of the tractor:

Right side \_\_\_\_\_ Left side \_\_\_\_\_ Other \_\_\_\_\_

INJURIES:

First Aid \_\_\_\_\_ Treated by Physician \_\_\_\_\_  
(name)

Hospitalized \_\_\_\_\_  
(name)

Nature of Injury (fracture, laceration, etc.) \_\_\_\_\_

Part of Body Injured (specify if more than one) \_\_\_\_\_

Estimated Length of Disability Days \_\_\_\_\_ Cost \_\_\_\_\_

Other Medical Information \_\_\_\_\_

EQUIPMENT

Tractor: Make & Model \_\_\_\_\_ Age \_\_\_\_\_

Master Shield in Place Yes \_\_\_\_\_ No \_\_\_\_\_ If not, why not \_\_\_\_\_

Throttle setting at time of accident \_\_\_\_\_

Other Information \_\_\_\_\_

Implement: Make & Model \_\_\_\_\_ Age \_\_\_\_\_

Were PTO shields in place? Yes \_\_\_\_\_ No \_\_\_\_\_ Describe \_\_\_\_\_

Types of shields \_\_\_\_\_

If no, why \_\_\_\_\_

If yes, their condition \_\_\_\_\_



Nothing Entangled? Yes \_\_\_\_\_ No \_\_\_\_\_

If yes, by: Spring-loaded pin \_\_\_\_\_ Bolts, keys, wires \_\_\_\_\_  
(specify)

Grease fitting \_\_\_\_\_ Universal joint \_\_\_\_\_ Others \_\_\_\_\_

Unknown \_\_\_\_\_ Describe \_\_\_\_\_

Accident Location: Tractor end of PTO \_\_\_\_\_ Machine end of PTO \_\_\_\_\_

### ENVIRONMENT

Weather condition: Temperature \_\_\_\_\_ Windy \_\_\_\_\_ Clear \_\_\_\_\_ Snowy \_\_\_\_\_

Rain \_\_\_\_\_ Other \_\_\_\_\_

Condition under foot: Dry \_\_\_\_\_ Wet \_\_\_\_\_ Slippery \_\_\_\_\_ Other \_\_\_\_\_

Visibility: Light \_\_\_\_\_ Dusk \_\_\_\_\_ Dark \_\_\_\_\_

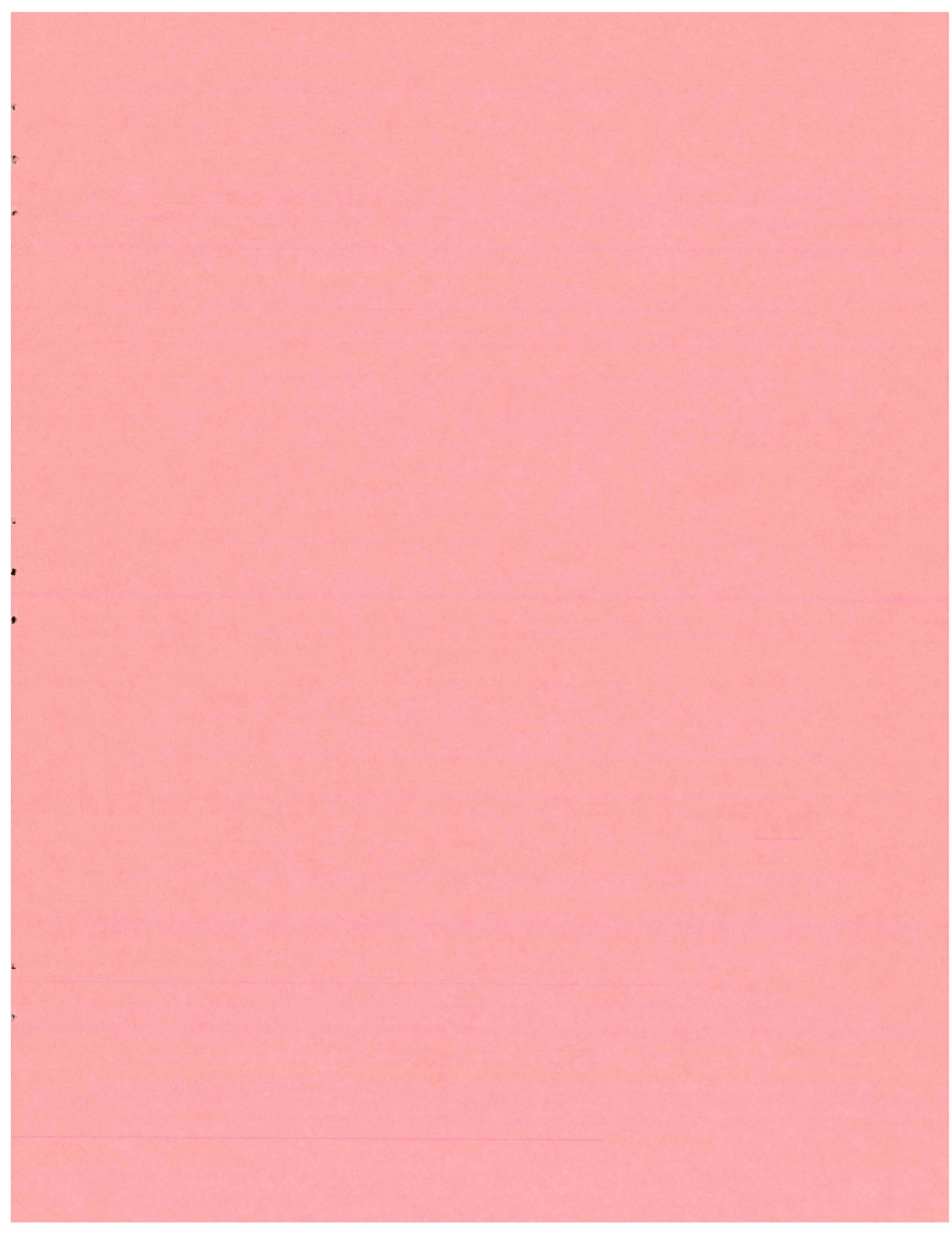
Noise Level(operator opinion) \_\_\_\_\_

Other conditions which may have diverted operator attention or disturbed him.  
(Ex.: Dust, dirty glasses, traffic, observers, emergency, etc.)

Describe \_\_\_\_\_

Was tape recording made of the interview? \_\_\_\_\_ Yes \_\_\_\_\_ No \_\_\_\_\_







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