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SAFETY EVALUATION OF CONVEYOR BELT CLEANING SYSTEMS

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FOREWORD

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SAFETY EVALUATION OF CONVEYOR BELT CLEANING SYSTEMS

by

Wm. Kleysteuber¹

ABSTRACT

This report presents the results of a study covering the safety evaluation of conveyor belt cleaners. The focus of the study was to determine the effectiveness of practical belt cleaning devices in removing the material that carries back past the normal discharge point from the return strand belt so that it can not fall off. The material that falls off becomes part of the spillage that requires manual clean-up and increases the miner's exposure to hazards. The problem was found to be much more complex than simply the removal of this material. The material becomes spillage by an interaction of the belt with the return roller that is governed by the characteristics of the carry-back material caused by moisture content and particle size distribution. These phenomena remain undefined as they are beyond the scope of work. The results of the test show that practically any type of blade held in intimate contact with the belting will reduce the amount of material carried back. Effective cleaning, however, requires high pressure on a blade material compatible with the carried back material in that it is not cut and grooved by the particles. Selection of cleaning methods is largely controlled by site-specific conditions at the installation and the end use of the product. This report defines engineering criteria that will increase the effectiveness of belt cleaning devices and methods and suggests a method to predict the costs of cleaning.

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Section 1

EXECUTIVE SUMMARY

Background

The troughed belt conveyor is used throughout the mining industry for the efficient transport of mined materials over short and intermediate distances. High liquid fuel costs have created a strong incentive for their increased use, and the spillage that accumulates in the area the belts traverse (figure 1) has become a major problem. This accumulation results when the material that is carried back by the return strand of the belt falls off under the structure (figure 2). This spillage interferes with the operation of the belt conveyor, and mine personnel are exposed to the hazards of moving machinery while cleaning up the material in dangerous and difficult work areas. The material carried back can also build up on pulleys and idlers (figure 3), causing premature failures. This build-up also tends to detrain the belting, putting it in contact with the structure, which damages or breaks the belting. The added downtime and repairs increase both the cost of operation and the hazard exposure time.

A MSHA accident analysis¹ shows that about one-half of incidents that happen around conveyor belts occur during clean-up and repair. The amount of spillage from a conveyor system can be related to the number of manhours required to clean up and, therefore, the exposure hazard for mine personnel. Although most of the spillage collects on the structure and floor under the return belting, some portion becomes airborne and is difused over the entire area. If the material is combustible, an explosion or fire hazard is created. In either case, the health of mine personnel is affected by the contaminated air.

¹R. L. Stahl. Analysis of Injuries Involving Conveyors in Metal and Nonmetal Mines, 1975-1976. Report from the U. S. Department of the Interior, Mine Health and Safety Administration, Health and Safety Analysis Center, Denver Colorado (undated), 7 pp.

Practical methods must be developed to increase the effectiveness and safety aspects of belt cleaning devices so that the mine operator will install and maintain the units. Present attempts by the mining industry to eliminate carry-back spillage have not been effective except under special conditions, such as where wet washing can be used.

The first goal of this program was to define and evaluate the problem areas. A literature search was conducted, an industry review was performed, and visits to plants using various belt cleaning techniques were made to establish the state of the art and to document application practices for existing hardware and designs. The second goal was to determine the effectiveness of the various generic cleaning actions available to minimize the amount of material remaining on the return strand of a conveyor belt. In addition, an attempt was made to determine the mechanism of spillage that results from the interaction of the return rolls and belting.

Approach

The initial program approach attempted to quantify the cleaning efficiency of commercial belt cleaning devices that remove the material clinging to the return belting. Cleaning efficiency was defined as the quantity of material removed by the device divided by the quantity of material clinging to the belt before the cleaning action. Following a field survey, however, it was determined that this measure would not give the industry useful information for selecting or using belt cleaning devices since cleaning efficiency could not be determined from a measurement of the gross amount of material clinging to the return belting. Furthermore, how the returned material became spillage could not be ascertained by using the initial approach. In addition, the commercial cleaning actions were determined to have a generic base that could be classified under the broad headings of wiper, scraper, brush, and special. (Laboratory tests later defined the difference between the wiper and scraper action to be governed by contact pressure.) Because of its inherent dust generating liability, the brush type was not considered practical for mining installations although it was tested to obtain base reference data. Belt cleaners defined to be in the special category were not included due to the number of independent variables they would have introduced

into the laboratory test program and because the phase I survey indicated that there were very few effective field applications.

The program approach was subsequently redefined and efforts were begun to determine the effectiveness of the various generic blade materials that fell into the wiper and scraper groups, which were considered to have practical application in mining. The effectiveness of these cleaners was measured in grams of material clinging to each square foot of belt surface after it was cleaned.

An effort was also made to relate the quantity of material carried back on the return strand to the quantity of spillage. Generally, the material that clings to the return strand does not come off the belting unless there is interaction with the idlers that guide and support the return strand. The mechanisms of this phenomenon are wiping, adhesion and a wringing-squeezing action between belt and idler. (These cleaning actions are defined in section 2.) "Wringing"--not identified until the Phase II laboratory tests--was found to be a major factor in creating spillage although it has some potential for becoming a useful cleaning action.

Activities and Results

In Phase I, pertinent literature, two proprietary site-specific studies, and an overview of commercial cleaners by Delft University were studied for useful information. To identify the more serious belt cleaning problems, visits were made to mines and plants with over 400 operating belt conveyors. During the site visits, material samples were taken and analyzed for particle size distribution and moisture content in an attempt to determine the characteristics of the material that clings to the belting. The data was used to design a test bulk material that represented a worst-case cleaning situation. The sample data also gave the first clues to modifications to the material's characteristics that occur during wiping actions. The material that is carried back is smaller in average particle size and higher in moisture content than the load material on the conveyor.

The phase II laboratory tests were designed to determine the effective cleaning ability of the more popular wiper and scraping materials and, if possible, to explain and correlate the amount of material that is carried back by the belting to the

amount of spillage. The test results conclusively established the spillage relationship which is necessary to estimate the amount of spillage generated. The estimating method postulated in this report, when applied to the test results, showed that 5 percent \pm 1 percent of the material carried back past each return idler was removed as spillage in 75 percent of the tests. More work is needed to verify and expand this method and to derive a method for estimating the amount of spillage that can be expected from specific conveyor lengths.

Conclusions

Commercially available belt cleaners are capable of reducing material carried back to less than 10 grams per square foot if installed and maintained properly. The key to success is belt contact at sufficient pressure with adequate provision for flow of the removed material away from the cleaner.

The previous concept that the difference between wiping and scraping is a function of the blade material was refuted by the laboratory tests. The difference between "wiping" and "scraping" is better defined by the blade contact pressure rather than the blade material. The contact area pressure is the governing factor, and at some critical pressure there is a dramatic increase in the effectiveness of cleaning. Contact pressures required for effective cleaning were found to be two to five times higher than previously specified by the manufacturers of commercial belt cleaners.

The potential exists for a large improvement in belt cleaning effectiveness by expanding on the basic findings of this program. By using a systems design approach, it is expected that the material that clings to the return belting can be further reduced to approximately 1 g/ft².

Section 2

BASIC BELT CLEANING MECHANISMS

2.1 Mechanisms Defined

Early in the site visits, it was apparent that all belt cleaners rely on one or more basic physical actions to overcome the adhesion of the particle to the belting surface. These can be described as generic cleaning actions, and the fundamental knowledge of how they functionally part the cling material from the belting is required to better understand their problems. The first twelve actions covered are all known methods used to clean conveyor belting. As a result of the laboratory testing, an additional action was added because it also has potential to clean belting.

2.1.1 Gravity

The principal method used for belt cleaning is the force of gravity, which causes particles with low adhesion to break a bond with the conveyor belt (figure 4). In cases where coarse particles are transported, the belt can be more effectively cleaned if the material has been screened to remove the fines.

2.1.2 Centrifugal Force

As the belt wraps around the head pulley, gravitational cleaning is enhanced by centrifugal force to dislodge the materials (figure 5). Under normal conditions, centrifugal acceleration increases the effect of gravity by approximately 10 percent. Increased belt speed and smaller head pulley diameters increase the centrifugal force.

2.1.3 Lopping

Lopping is a planing action achieved by placing a hard, sharp blade at a low angle to the belt. This causes a parting in the clinging material near the belting surface by shearing through the material (figure 6). This type of rough cleaning is normally done at the head pulley and involves a substantial risk of damaging the belting.

This action differs from scraping in that the material is not blocked but is simply sheared and deflected from the belting.

2.1.4 Wiping

Placing a friction surface in low-pressure contact with the material clinging to the belting surface retards the material's speed to below that of the belt (figure 7). This reaction breaks the adhesion and causes the contacted particles to fall away from the belting.

2.1.5 Scraping

A barrier with near zero clearance is held in high-pressure contact against the belting to physically block clinging material from traveling with the belting (figure 8).

2.1.6 Brushing

A series of bristles are placed in the path of the clinging material to reduce the velocity of the particles (figure 9). Depending upon the force and the stiffness of the bristles, the basic actions are wiping and/or scraping.

2.1.7 Vibrating

The dislodgement force is increased by the accelerations produced by vibrating or beating the belting.

2.1.8 Bending

By running the belting around small-radius idler pulleys, centrifugal force is used to dislodge material. This action also tends to crack loose any material cemented to the belt.

2.1.9 Fluid Pressure

Fluid impingement assists in breaking the adhesion of the clinging particles. The fluid fills the voids between the material particles, acts to decrease adhesion at the material/belt interface, decreases the strength of the materials, and breaks up

the compaction. This action can be effective using either a liquid (figure 10) or gas.

2.1.10 Parting Compounds

The surface of the belting is chemically treated to decrease the particle-to-belting adhesion.

2.1.11 Cover Materials

A belt-covering material that minimizes adhesion between belting and particles is selected.

2.1.12 Surface Adhesion

By bringing another surface in contact with the clinging material, the particles stay with the new surface. This works best in a wet environment.

2.1.13 Wringing

The action of the return roll establishes a pressure barrier that retards the material clinging to the belting in an accumulation (figure 11) at the contact area.

2.2 Mechanisms Discussed

2.1.1 Single Blade (Figure 7)

A single-blade mechanism is applied in most cases to clean conveyor belts. This type of mechanism consists of a single piece of material placed across the width of the belt. The simplest configurations are fixed, using the flexibility of the rubber wiper to apply the force against the belting (figure 12). Various hardware is used to maintain the pressure for an extended adjustment interval on more complex units. Spring loading, counterweighted, or torsion arm devices are typically used.

Many different blade materials, such as soft rubber of 40 durometer on the shore A scale, hard rubber of 80 durometer A, urethane, and in some cases, a hard-faced steel are used.

The single blade type is acceptable for rough cleaning and as a preliminary cleaner for removing large particles that loosely adhere to the belt. The major advantage is low initial cost and simplicity; however frequent adjustments and blade changes are required.

The major drawback of single blade units is the wear pattern. The blade material wears away faster in the center of the blade (see the air gap present between the blade and belt in figure 13) where the buildup causes heavy abrasive wear. Under these conditions, the blade is in contact only on the belting edges, leaving a section near the center of the belt that is not adequately cleaned. The cleaning action is characterized as wiping, mild scraping, and depending on the blade angle to the belting, lopping.

2.2.2 **Multiblade** (Figure 14)

The multiblade type of belt cleaner consists of a series of single blade cleaners which give an extended life cycle. Because pressure on the blades is reduced, they also have longer maintenance cycles, and belt cleaning is improved due to their series action. Their major drawback is the adverse wear pattern of the blades.

2.2.3 **Segmented Blade** (Figure 8)

The segmented-blade cleaner consists of a line of small blades placed across the belt width, wherein each blade is individually loaded. The most popular method of loading is by spring arms but counterweight and coil spring types are also used. Typically, there is articulation between the arm and the blade to maintain contact under uneven wear patterns. In some cases two sides of the blade are available for wear.

In general, this type of cleaner does the most acceptable cleaning job over the broadest range of conditions. Blade materials vary from hard rubber, urethane, and ceramic, to tungsten carbide inserts in steel. The major drawbacks of the harder materials are their potential for damaging the belting and their inherent incompatibility with normal mechanical belt splices.

2.2.4 Rotary-Powered Cleaners (Figure 9)

These units rotate a drum against the belt with motion counter to belt travel. This increases the speed of the wiping surface with respect to the belting. The drum can be fitted with brush bristles, fluted rubber, rubber fingers, or material in a helix configuration. These cleaning surfaces apparently do as good a job as do multiple wipers; however, dust generation can be a problem. The bristle brush units work best for dry materials.

High installation costs and maintenance requirements have led to minimal use of rotary-powered cleaners.

2.2.5 Pneumatic Cleaners

These units are used primarily to remove wet, sticky, and highly abrasive materials. Two types of pneumatic cleaners are available, low pressure blower and compressed air. Low pressure blower units use motors up to 10 hp for a 48-inch-wide belt. High pressure compressed-air units require approximately 600 cfm, or the total output of a 125-hp compressor, for a 48-inch-wide belt. These units can cause serious dust problems as the material dries; hence, they have a very limited application.

2.2.6 Wet-Wash Cleaners

Low pressure (40 psi) wet-belt washing (figure 10) is used extensively in the sand and gravel industry where wet screening of the material is required. These units are essentially trouble free and operate effectively and inexpensively as long as process water and treatment are available in the plant. Wet-wash cleaners are not appropriate where conveyor systems are operated in below freezing temperatures.

High pressure (3000 psi) units are available but installation and maintenance costs are high; hence their application is limited.

2.2.7 Chemical Treatment of Belting Surface

This method sprays a parting compound on the belting and relies on the natural cleaning action to overcome the reduced adhesion of the material to the belting. These compounds rely on hydrophobic actions and are not recommended for use on dry materials. This method is expensive; therefore, its application is limited to very special cases.

Wipers and scrapers of the blade type and low-pressure wet-wash cleaners account for almost all belt cleaners used in the mining industry. In all the installations visited, the single-blade wiper with a rubber blade predominated.

Section 3

BELT CLEANER APPLICATION

3.1 Material Considerations

The basic consideration in belt cleaning is the bulk material being handled and its readiness to cling to the belting. The problem of spillage starts with the tendency of a bulk material to cling to the surface of conveyor belts in spite of the action of the normal forces (gravitational and centrifugal) which are trying to dislodge it at the discharge point. An analysis of the actions and reactions of the material as it is loaded, transported, and discharged by a belt conveyor is necessary to better understand this situation.

As a material is dropped onto the moving belt at the loading point, frictional forces between the belting surface and the material particles bring the material to the speed of the belt. The finer the material particle, the more quickly belt speed is attained. Thus, there is a natural tendency of the conveyor system to initially bring the fine material in intimate contact with the belting surface. As the settled material is transported, the kneading action of the carrying rolls work the material, thus allowing an additional concentration of fines to sift downward onto the belting surface. At the same time, entrapped air and excess water mixed with the material is expelled. As this process of compaction continues, the fines continue to accumulate at the bottom of the load. The finer the material in contact with the belting, the greater the adhesion per increment of weight*. The higher the compaction, the greater the cohesive, shear, and tensile strength of the material.

At the discharge pulley, the natural forces inducing dislodgement are centrifugal and gravitational. These two forces must combine to overcome the adhesion between the conveyed material and the belting. In addition, air must flow into the void created by the dislodgment. The cohesion of the material does not allow this

*For each half size of a material, the value of adhesion to weight doubles.

air flow, and a vacuum force tends to support the adhesive force. Most natural parting actions occur through shearing of the layer of material close to the belt surface rather than at the contact line between material and belt because the former is a weaker plane. For these reasons, it can be concluded that permeability of the material is also a factor in dislodgment at the discharge point. Permeability is decreased by compaction and the proper degree of moisture content.

To clean a belt surface effectively, the cleaning action must be of sufficient pressure to make and maintain a contact that blocks the clinging material from passing. Apparently this pressure is somewhat independent of the blade material since clear scraping was achieved with materials that varied from soft rubber to tungsten carbide. Below the critical pressure transition zone, the parting occurs along a plane parallel to the belt surface by shearing through the material, leaving a layer of fines adhering to the belting (figure 15).

Some additional removal is precipitated by frictional contact of the larger particles in the layer of fines contacting the blade material, where they are retarded to less than belt speed and fall away from the belt as they exit the blade (figure 16).

3.2 Basic Requirements for Cleaning

How clean the return strand of a belt cleaner must be to be satisfactory must be defined on a site-specific basis. The problem of removing the material carried back from the return strand is more complex than just dislodging the material that clings to the belting. This is only the first step. The second step is to remove the material from the cleaning device so that its ability to function is not impaired (figure 17). The third step is to remove the cleanings from the surrounding area so that the cleaning device is not inundated (figure 18). And the last step is to return the cleanings to the transport system or to an ancillary disposal system. In a typical head-end design, the space to perform these necessary functions has not been allotted. Even the placement of an effective cleaner is difficult in most cases (figure 19), so the first problem is in the compatible design of conveyor head ends and cleaning devices.

The next problem is to determine what quantity and size of hauled material will cling to the belting. Figure 15 illustrates a belt where the material carried back

after the wiper was 10 grams per square foot. For a 48-inch-wide conveyor with a 500-fpm belt speed, the total would be 10 tons per shift. At the installation in figure 21, it was obvious that almost all of the material carried back was being recycled as opposed to falling off since less than half the amount of material would have filled the tail pulley area during each shift. The quantity of material carried back will vary with the moisture content, particulate size, composition, temperature, belting cover material, etc.

Adhesion of a bulk material to a conveyor belting cover occurs only when fine materials are present and will increase with an increase in moisture content to some maximum level then decreases as the material tends to slurry. Typically, cohesion does the same; therefore, the points of maximum adhesion and cohesion should be where maximum amount of material is carried back and this should coincide with the highest internal shear strength.

By having some idea of the characteristics of the material when it reaches the worst conditions, a cleaning approach can be selected to satisfy health, safety, and operational considerations of the specific conveyor installation. This report does not address the relationship between the material carried back and the spillage because no clear understanding of that phenomenon was developed. The essential fact is that, in general, spillage reduces with reduced material carried back but not necessarily in direct proportion. Where the spillage occurs and in what mode is still unpredictable without a specific study.

The material characteristics are modified by cleaning actions, which cause large changes in moisture content, particle size, and size distribution. The return rollers cause further change by concentrating and agglomerating the material carried back (figure 20). The principal cause of spillage is the carried-back material sticking to the return roll surface and accumulating until it falls away to become float dust or builds up under the conveyor (figure 21).

After the foregoing considerations and effects are evaluated, the basic cleaning approaches required to accomplish the desired results can be appraised. Each approach will have different effects on the quantity, characteristics, and particle size of the material remaining after the cleaner and their reaction to influences

that cause spillage. Some approaches may be unacceptable to product quality or the desired end use. At present, the ability of the various cleaning approaches to function effectively under the wide changes in the characteristics of the hauled material, the cleaners' effect on the characteristics, and how all this influences the spillage quantity and quality has not been established.

Because of the characteristics of the material that clings to the return strand, the fraction that is cleaned from the belt is fine, so when dry it becomes airborne dust. Moisture makes the material highly adhesive and cohesive and, in general, it has poor flow properties (figure 21). The result is a build-up of high strength deposits on the cleaning device that can effectively stop further removal (figure 17). The frictional heat generated by the cleaner tends to "bake on" these deposits. Removal of the accumulation can be done routinely but a continuous cleaning action is highly desirable. Conditioning the carried back material by adding moisture to make the scraped off material flow is a generally satisfactory solution. The added moisture also tends to cool the blade material, greatly reducing the wear rate of elastomeric compounds. Conditioning will also eliminate the tendency of the fines to become airborne and aid the flow of the removed materials in the chute work below the cleaner installation.

The primary function of the hardware that supports the cleaner is to keep the cleaner surface in constant contact with the belt surface with the pressure evenly distributed across the interface. This is most difficult to accomplish due to the unevenness of belting surface and the differential wear patterns of the cleaner blade that occur during use. As well as underloading, the hardware cannot permit overloading. Overloading causes cover damage on the belting, by concentrating the force on a small area where there is a bump in the belting and kinetic overloading when the weight holding the cleaner in contact must move to allow passage of humps projected through the belting. Elastic blade materials tend to counteract spot overloading by deforming and spreading the force over a wider area. Various other parameters requiring site-specific inputs for evaluation are cost, maintainability, splice compatibility, reliability, durability, downtime requirement, head-end design, power consumption, and failure modes.

3.3 Limitations

3.3.1 **Wear**

Belt wear is the dominant consideration in belt cleaning (except in noncontact types--fluidic and parting compounds). Literally, the materials that stick to the belting are grinding compounds that remove cleaner material and belting cover. The control of wear on the cleaner is important, but small in contrast with the cost of belting plus the downtime and manhours required for replacement. Belt cleaners should not appreciably accelerate wear on the belting cover. There is a positive trade-off for belt cleaning because the build-up of material under the conveyor and on return idlers can cause excess belting wear (figure 3).

Pressure of the cleaner against the belting must be controlled in a relatively narrow band. Too high a pressure causes the cover to be peeled off by the blade and too low a pressure allows a layer of material to grind between the interface. The important point is to maintain the minimum pressure that effectively establishes the parting line at the belt surface. One condition attributed to accelerated wear on elastomeric cleaner blades is actually melting of the material from frictional heat. The use of water prior to the blade contact can alleviate the problem by cooling the blade. Blades for effective cleaning and wear control fall at two extremes: A hard material, such as carbide, or a soft elastic material, such as rubber. The elastic materials are not prone to cause cover damage and are more compatible with mechanical splices than carbide, but effective cleaning pressures are difficult to sustain (figure 22). The elastic properties that allow the material to conform to the irregularities in the belting surface cause deflections and bending under the pressure required for effective cleaning.

3.3.2 **Build-Up**

If an effective cleaning action is not cleared of the material that is removed, the action deteriorates, and the unit can become useless. Two types of build-up occur: build-up that increases the contact area, reducing the contact pressure (figure 17), and build-up that inundates the cleaner (figure 18), bringing the removed material back in contact with the cleaned belting. The material removed by cleaners has poorer flow characteristics than the load carried by the conveyor. The chutework designs at conveyor head end usually do not allow for the flow of the material back

into the system. Material that adheres to the blade becomes a hard mass baked on by the frictional heat of the blade contact.

Both problems can be alleviated by adding water (in cold temperature, an anti-freeze) in sufficient amounts to turn the cleaned off material into a slurry, which will flow off the blade onto the chutework. Other solutions, although workable, tend to add more complexity and maintenance problems than do periodic manual clearing.

Build up of material on the conveyor machinery is another problem. The ultimate result is that these accumulations can accelerate wear on the machinery (figure 23) and detrain the belting so that it contacts structural members and is damaged. The mechanism of this type of build-up is difficult to explain or predict because of the variables and the interaction between them. The particle size distribution, moisture content, and adhesion on belting and idler rollers are the principal factors. Large detrimental build-ups (figure 24) can grow from small carry-back loads under the proper conditions. These conditions seem to be aggravated by ineffective cleaning. The simplistic solution is to completely clean the return belting, but some practical results can be accomplished by control of the moisture content to keep the material above or below the cohesive range.

The build up on idlers and pulleys is size selective. In the process the material sticking to the belting selectively supply the particle size distribution needed to cement large accumulations together. The size distribution curve of figure 25 is the material build-up on the return idler shown in figure 3. The size distribution curve of figure 26 is from a sample of the source material. This illustrates that even if the source material has a minimum amount of fines, the process will selectively pull enough fines from the carried back material to supply the particle size distribution that will cement together to cause large build-ups.

3.3.3 Maintainability

One firm requirement for maintainability is that routine maintenance of a belt cleaner must be possible while the conveyor is running to minimize downtime on the conveyor, and, more importantly, alleviate exposure to hazards for the mine worker. This is the primary justification for using some of the expensive,

specialized cleaners, such as parting compounds and pneumatic and high-pressure washing. Two commercial units—a lopper (figure 27), and a segmented scraper (figure 28)—are designed to allow the blades to be removed for service while the conveyor is running. One type of maintainable shop-made wiper is shown in figures 7 and 22. These drop-in wipers are removed for service by releasing two elastic bands and lifting the unit from the C-slot. It is then lowered to the floor and removed outside the structure line for service. This requires access to both sides of the conveyor, clearance below the return strand, and two workers to safely perform the maintenance. Although belt cleaners that can be serviced while the conveyor is running are the exception, the foregoing illustrated designs show that it is possible, with a little ingenuity in concept.

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Section 4

DESCRIPTION OF THE TEST FACILITY, MATERIAL, AND APPARATUS

4.1 The Test Facility

The test conveyor is a 36-inch-wide by 35-foot-long, 10-hp, troughed belt conveyor (figure 29). The speed of the belt can be varied from 150 to 330 fpm by a manually controlled, variable pitch, V-belt arrangement (figure 30). The discharge from the belt conveyor is recycled through two 10-inch-diameter screw conveyors and a 6-inch centrifugal discharge belt bucket elevator (figure 31) into a chute that discharges onto the belt before the spreader (figure 32). The system capacity is constricted to less than 25 tons per hour by the bucket elevator.

4.2 The Test Material

The recipe for the test material was derived to present a worst-case situation for belt cleaning. From the field observations, the tenacity of the mason sands and fine limestone caused the most problems with material that carried back and built up. The test material is 75 percent (-800 micrometer) sand and 25 percent (-100 micrometer) limestone. Maximum shear strength occurs in the 12-percent moisture range.

The adhesion and cohesion are high enough that a 1/2-inch-thick layer of the material will carry back if moisture is kept below 22 percent. The limit of the carry-back thickness was dictated by the recycle system capacity and not the characteristics of the material.

The sand portion contained sufficient sharp particles to make the material abrasive and the pulverized limestone added the cohesion. In testing the material has the appearance and characteristics of a medium slump mortar mix.

4.3 The Test Apparatus

The test apparatus consists of a row of pneumatic cylinders (see figure 33) that apply a controlled force to individual blade mounts. The cylinder pressures are controlled by regulators fed from a 1-hp portable air compressor. The blades are mounted on 5/8-inch rods with pivots forward of the contact area so that the drag force on the blade is transmitted laterally to the cross shaft and no reaction force is put on the pneumatic cylinders.

Section 5

TEST RESULTS AND OBSERVATIONS

The tests were broken into two series. The first series attempted to define effectiveness of cleaning and to define the relationship between the amount of material carried back and the amount of spillage. The test procedure (outlined in the appendix) was designed to measure the loads of the carrying side, the amount of material carried back, the spillage, idler buildup, and the material carried back over to the top strand on the test belt when various commercially used belt cleaner blade materials were in contact with the belt. Analysis of the results would hopefully give a method of predicting the amount of spillage as a function of the blade material.

Prior to laboratory testing, all the literature, field observations, and expert advice lead to the belief that blade materials were the controlling factor. Soft elastomeric blades reportedly did wiping and hard blades did scraping. So the designed functions of the test apparatus (described in section 4) was to assure that the blades were held in contact with the belting at an equal and controlled pressure between 8 to 16 pounds per blade with blade widths of 5 to 6 inches. The major concern was to assure 2 to 3 pounds per inch of blade width to accomplish good belt cleaning.

The results of these test series (table 1) were erratic and inconclusive. Analysis showed they could not be used for predictive modeling, presumably because the assumptions used as a basis for the investigation were wrong.

The first indication that contact area pressure is the principal factor was during run-in times when the maximum blade pressure capabilities of the test apparatus was used to accelerate blade wear in an attempt to get total belt contact. As the blade wore-in (contact area increased) the cleaning effectiveness decreased. The line contact of a new blade, particularly if installed with a rake angle, produces the high scraping pressures needed for effective belt cleaning. This agrees with field observations and assertions that cleaning effectiveness is improved by blade

changes. In retrospect, the data indicated that there were two different groupings of the amount of material remaining on the return belting and that the change over from wiping to scraping was the determining factor.

The second test series (procedure described in the appendix) was designed to determine the reason for erratic data in the first test series. The data showed a dramatic shift in the amount of material carried back. So much so that it plots as two separate curves (figures 34 through 37). The change is distinct in the urethane and rubber blades. In the carbide blade test, observation showed that the areas of ineffective cleaning were caused by defects in the surface of the head pulley, which did not provide a smooth backing for the belting (see the right side of figure 38). It is believed that a smooth back-up for the belt would have produced curves similar to urethane. The high-density polyethylene (HDPE) blade wore rapidly, apparently from high-spot melting and abrasion. It never effectively scraped more than one inch of belting (see position 3, figure 39). This points to the influence of the blade material. If the blade material can be scored by the material carried back, clean scraping is impossible because only the top of the grooves touch the belting.

In the test descriptions that follow, C, T, and S suffixes have been added to the test number to indicate commercial, test, and standard belt cleaner configurations, respectively. The commercial units were tested to validate the test setup; the test configurations addressed cleaner mechanisms of interest; and the standard configuration was present during all series 1 tests for reference.

Description of the Tests in Series 1

The first three tests in series 1 (see table 1) were for the purpose of establishing baseline data of commercial belt cleaners to compare to the special designed test apparatus. The lopping type of cleaner installed at the head pulley served two purposes: (1) to help spread the load evenly and (2) to hold the quantity of carried back material to a manageable level. Without this cleaner the entire belt load would carry back to the first return idler. This would inundate the pans used to collect the spillage in less than one minute of run time. NP Test 1C was an equipment and procedure shakedown run.

TABLE 1. Summary of Series 1 Test Results

Test No.	Action Description and Series	Pressure (psi)	Moisture Content (%)	Belt Speed (fpm)	Load on Belt (g/ft ²)	Material Carried Back (g/ft ²)	Spillage (g/ft ²)			Material Sticking to Return Rolls (g/ft ²)			Material Carried Over to Top Strand (g/ft ²)	Run Time (min)
							Sta. 1	Sta. 2	Sta. 3	Sta. 1	Sta. 2	Sta. 3		
1C	1. Urethane Lopper	12.0		150	1134	*	*	*	*	*	*	*	*	*
	2. 7-Blade Carbide	24.0	13.0	150	1134	6.86	0.27	0.01	1.14	*	*	*	5.35	43.5
2C	1. Urethane Lopper	12.0		150	1225	*	*	*	*	*	*	*	*	*
	2. 7-Blade Carbide	40.0	13.0	150	1225	2.55	0.14	0.15	0.13	*	*	*	5.39	240
3C	1. Urethane Lopper	12.0	13.0	150	1225	31.00	1.13	1.30	1.16	*	*	*	37.42	30
1T	1. Urethane Lopper	12.0		150	359	*	*	*	*	*	*	*	*	*
	2. Pneumatic 7-Blade Carbide	24.0	13.5	150	359	4.25	2.19	0.31	0.13	850	936	2381	5.32	120
3T	1. Urethane Lopper	12.0		150	731	*	*	*	*	*	*	*	*	*
	2. Pneumatic 7-Blade Carbide	24.0	13.5	150	731	7.95	0.98	0.22	0.69	567	397	680	7.79	240
4T	1. Urethane Lopper	12.0		151	1055	*	*	*	*	*	*	*	*	*
	2. Pneumatic 7-Blade Carbide	40.0	13.5	151	1055	2.84	0.18	0.05	0.12	567	454	1134	11.34	240
4C	1. Urethane Lopper	12.0		152	686	24.00	*	*	*	*	*	*	*	*
	2. Blank		14.7	152	686		0.23	0.02	0.66	425	85	425	9.64	240
	3. Bristle Brush, 10-Inch Rotating			152	686	10.77								
5S	1. Urethane Lopper	12.0		151	1219	28.00	*	*	*	*	*	*	*	*
	2. Pneumatic 4-Blade Carbide	12.0	14.6	151	1219	20.41	1.71	0.26	0.56	283	28	241	15.31	60
5T	1. Urethane Lopper	12.0		151	1219	28.00	*	*	*	*	*	*	*	*
	2. Pneumatic 4-Blade Carbide	40.0	14.6	151	1219	6.24	0.34	0.11	0.23	468	142	454	4.25	60
6S	1. Urethane Lopper	12.0		150	680	28.00	*	*	*	*	*	*	*	*
	2. Pneumatic 4-Blade Carbide	12.0	17.0	150	680	20.70	1.19	0.27	0.36	425	57	227	9.92	60
6T	1. Urethane Lopper	12.0		150	567	28.00	*	*	*	*	*	*	*	*
	2. Pneumatic 4-Blade Urethane	18.6	17.0	150	567	12.19	0.23	0.04	0.24	312	28	142	7.09	60
7S	1. Urethane Lopper	16.0		150	538	19.00	*	*	*	*	*	*	*	*
	2. Pneumatic 4-Blade Carbide	12.0	17.0	150	538	14.46	2.24	0.27	1.04	340	31	255	12.19	32
7T	1. Urethane Lopper	16.0		150	510	19.00	*	*	*	*	*	*	*	*
	2. Pneumatic 4-Blade Urethane	12.0	17.0	150	510	12.76	4.19	0.20	1.29	765	85	284	7.65	32

8S, 8T Aborted

* Not sampled.
! 1/8-inch contact.
Suffixes C, T, and S denote commercial, test, and standard cleaner configurations, respectively.

TABLE 1. Summary of Series 1 Test Results - Concluded

Test No.	Action Description and Series	Pressure (psi)	Moisture Content (%)	Belt Speed (fpm)	Load on Belt (g/ft ²)	Material Carried Back (g/ft ²)	Spillage (g/ft ²)			Material Sticking to Return Rolls (g/ft ²)			Material Carried Over to Top Strand (g/ft ²)	Run Time (min)
							Sta. 1	Sta. 2	Sta. 3	Sta. 1	Sta. 2	Sta. 3		
9S	1. Urethane Lopper	12		152	340	34.02	*	*	*	*	*	*	*	*
	2. Pneumatic 4-Blade Carbide	20	19.0	152	340	17.86	1.50	0.09	0.54	*	*	*	10.40	60
9T	1. Urethane Loper	12		152	425	34.02	*	*	*	*	*	*	*	*
	2. Pneumatic 4-Blade Urethane with Ceramic Inserts	20	19.0	152	425	24.10	**	**	**	*	*	*	11.34	60
10S	1. Urethane Lopper	12		151	425	*	*	*	*	*	*	*	24.10	30
	2. Pneumatic 4-Blade Carbide	20	18.5	151	425	34.59	**	**	**	*	*	*	*	*
10T	1. Urethane Lopper	12		151	425	*	*	*	*	*	*	*	*	*
	2. Pneumatic 4-Blade High Density Polyethylene	20	18.5	151	425	34.59	**	**	**	*	*	*	34.59	30
11S	1. Urethane Lopper	12		151	425	*	*	*	*	*	*	*	*	*
	2. Pneumatic 4-Blade Carbide	25	18.0	151	425	19.56	**	**	**	*	*	*	19.56	60
11T	1. Urethane Lopper	12		151	425	*	*	*	*	*	*	*	*	*
	2. Pneumatic 4-Blade High Density Polyethylene	25	18.0	151	425	32.88	**	**	**	*	*	*	32.88	60
12S	1. Urethane Lopper	6		151	440	52.45	*	*	*	*	*	*	*	*
	2. Pneumatic 4-Blade Carbide	12	17.0	151	440	23.25	1.96	1.58	0.17	*	*	*	12.76	65
12T	1. Urethane Lopper	6		151	305	52.45	*	*	*	*	*	*	*	*
	2. Pneumatic 4-Blade 85-Durometer Rubber	12	17.0	151	305	14.74	0.70	0.50	0.12	*	*	*	14.18	65
13S	1. Urethane Lopper	6		152	567	41.11	*	*	*	*	*	*	*	*
	2. Pneumatic 4-Blade Carbide	12	19.0	152	567	29.77	*	*	*	*	*	*	18.71	30
13T	1. Urethane Lopper	6		152	567	41.11	*	*	*	*	*	*	*	*
	2. Pneumatic 4-Blade Ceramic	12	19.0	152	567	21.55	*	*	*	*	*	*	14.74	30
14S	1. Urethane Lopper	6		331	201	53.86	*	*	*	*	*	*	*	*
	2. Pneumatic 4-Blade Carbide	40	17.5	331	201	4.25	*	*	*	*	*	*	1.13	58.5
	3. Rotary Brush	!!		331	201	4.25	0.01 total at all three stations							
14T	1. Urethane Lopper	6		331	201	53.86	*	*	*	*	*	*	*	*
	2. Pneumatic 4-Blade Mild Steel, 60-Degree Angle	40	17.5	331	210	18.43	*	*	*	*	*	*	8.50	58.5
	3. Rotary Brush	!!		331	201	7.09	0.02 total at all three stations							

* Not sampled.

** Idlers removed; no fall-off.

! 1/8-inch contact.

!! 1/16-inch contact.

Suffixes C, T, and S denote commercial, test, and standard cleaner configurations, respectively.

Test 2C was made with the segmented type of commercial cleaner (figure 40) carefully assembled to maintain an even, high pressure on the blades to accelerate wear in and establish a best-case effectiveness of this cleaner type.

Test 3C was run to establish the levels of carried back material and spillage with only the lopper type of cleaner engaged, and it was expected that the amount of material carried back would remain relatively constant through all the testing.

The major problem encountered was with the recycle system (see appendix B), both from underpower of some of the conveyors and transfer chute plugging. Vibrators were installed at the major problem area on the elevator in hopes that the moisture content of the material could be kept close to its maximum shear strength. The final solution required adding moisture to lower the material shear strength so that it would not form arches over the transfer point openings.

Test 4C was run using a counter-rotating plastic bristle brush (figure 41) to establish a baseline for power cleaners under the testing conditions. The results show a considerable amount of material carried back but relatively low spillage. Apparently there is a change that occurs in the material that sticks to the belting that results in greater adhesion. The same results appear again in a test 14.

The test apparatus was installed and a three test set was run to assure that the action reasonably reproduced the results of commercial cleaners. Test 1T was a shakedown run and promptly showed that the carbide blades were not compatible with the Flexco type "SR" belt splice. An innovative solution was found by brazing a 3/4-inch flat washer to each end of the blade to form ramps (figure 42) that lifted the blade off the belting when the splice was contacted. These ramps achieved complete splice-blade compatibility throughout the testing without any discernable damage to the belt cover.

Test 1T was finished after numerous jams and clogs of the recycle system. The amount of material carried back was lower than expected probably because the new blades were not fully seated exhibiting a sharp edge that increased the contact pressure. Test 2T was started with a dryer material but soon abandoned due to the dust generated.

Test 3T was a calibration test of the apparatus to make a comparison of the results to the commercial cleaner, which were operated under similar conditions in test 1C. The results were comparable, indicating the apparatus did produce representative cleaning abilities of commercial cleaners.

Test 4T, made in comparison to test 2C, indicated that reproducibility was verified over a wide operating range, from 12 to 40 psi.

On test 5, the apparatus was set up to compare the blade material under test to a standard blade material operating under identical conditions. The variables from test to test were not completely controllable, but the procedure was designed such that they could at least be comparable between the test blade and a standard blade during each test. This was accomplished by cleaning one-half of the belting with the standard 1/4-inch by 5-inch carbide insert blades while the other half of the belting was being cleaned by the blade material under test (figure 38). Spillage was collected in pans placed under the belt (figure 43), and the samples of the material carried back, sticking to the return rolls, and carried over to the top stand were accumulated by manual scraping and cleaning at the end of each test. In this test, the effectiveness of the cleaning action was shown to increase with an increase in contact pressure from 12 to 40 psi, reducing the amount of material carried back from 20.41 to 6.24 grams per square foot.

During the remainder of this test series, frozen material and break-down in the recycle system caused constant interruption of the tests. An increase in moisture content and reduction in belt load were attempted to increase operating time. Shortening of test run times was required, however, due to frequent breakdowns and an effort to test the maximum number of blade materials.

Tests 6 and 7 compared 85A durometer urethane blade to the standard carbide insert blade at equal pressure. Test 8 was aborted due to equipment failure.

Test 9 compared a urethane blade with cast in 1/16-inch to 1/4-inch diameter ceramic beads to improve wear properties to the standard carbide insert blade. Within a short time (about 30 minutes) the smaller beads wore to half-diameter and began to cut into the belting cover. At the end of the test there were noticeable

grooves on the test side and cover material was in the material that was scraped off the belting. The cleaning effectiveness was less than the standard. This is not considered an acceptable blade material because of those faults.

In tests 10 and 11, a high density polyethylene (HDPE) 98A durometer was compared to the standard. HDPE was tested because it is an inexpensive blade material, but it did not scrape clear at any pressure attained in the laboratory. The HDPE was cut by the larger "carry-back" particles, leaving grooves for finer material to pass, which caused very rapid blade wear. HDPE is not considered a viable material for effective scraping on any load material hard and sharp enough to cut into the blade.

Test 12 compared an 85A-durometer rubber blade to the standard carbide insert blade. The results showed the rubber blade to be most effective as a cleaner at low contact pressures, thus explaining its widespread use in the industry. Why the results are better than other materials at low pressure is not completely understood. It is possible that local contact areas of the flexible blade develop relatively higher contact pressures.

Test 13 compared a high-alumina ceramic blade with a 9-MOH scale hardness fitted in a 1/8-inch stainless steel holder to the standard carbide insert blade. This material was expected to have excellent wear qualities; however, the blade material was not compatible with the mechanical splice installed on the test belting. Splice contact chipped and broke the ceramic along the leading edge. Splice jumpers were brazed to the stainless steel envelope but were not entirely successful. As the ramps contacted the splice, it initiated a differential movement between the envelope and the ceramic, causing the holder to contact the belting and shave the cover surface.

The final test (14) in this series was an attempt to demonstrate what the principal investigator thought would be the most effective belt cleaning attainable. Mild steel blades with a 60-degree positive angle of contact were compared to the standard. Both actions were followed by a powered rotary brush. The resulting data shows that the brush had little effect on the amount of material carried back on the standard side. The data from the test side of the belt shows that the

amount of material carried back was almost double the standard side with the carbide insert blade, and it was assumed that the 60-degree blade angle was not a success. But in retrospect, based on an analysis of the second test series, the poor performance was probably caused by the mild steel blade material that was selected to accelerate the wear-in period. The mild steel was cut and grooved by the carry-back particles, indicating that it was incompatible with the test materials for this application.

Analysis of the test data combined with observations during this series made it evident that a fundamental understanding of the belt wiping-scraping phenomenon was missing. The scatter of the data was not consistent with any concept proposed. The only indication that a dramatic change in carry-back occurred at some critical pressure was a few isolated data points that were gathered during test operations. A second series of tests was performed, and even then the phenomenon was not identified until the data was recognized to lie along two separate curves.

Interpretation of Test Series 2 Results

The second series of tests were run to "fill in" the gaps in the data observed during the former series of tests. These tests involved contact pressures up to 40 psi for 4 different blade types, including urethane, carbide, high density polyethylene, and rubber. Figure 34 shows a plot of the amount of carried back material to area pressure on a carbide blade. A distinct change in form and a shift of the curve is quite clear. This break would be more abrupt if the blade had been able to maintain constant contact (position 2, figure 39) over the whole interface, but irregularity of the belt and the belt backup (lagged head pulley) caused low pressure or no contact areas to pass.

The curves shown in figure 35 illustrate what is believed to be a truer indication of the amount of carried back material to pressure on the contact area (position 1, figure 39). Although the urethane blade was operated at the same time and conditions, the cleaning was better because the elastic properties allowed the blades to conform to a greater range between the high and low areas of the head pulley. The urethane blades were slow to wear in under the test conditions. In this series, inspection of the blade after completion of the tests (approximately 28

hours run time) showed only 80 percent of the surface had seated and was in high pressure contact. This was allowed for in the data by increasing the calculation pressure 20 percent but not in the photographs, which show the cleaned belting. The urethane pulled together all the desirable blade features needed for effective cleaning. The major drawback is friction can generate enough heat to soften the material causing rapid wear so a coolant would be beneficial.

The plot in figure 36 is of a 65A-durometer rubber blade (position 4, figure 39). It is interesting to note that the critical pressure appears to be 5 psi lower than other blades. The probable explanation for this behavior is that it was due to the horizontal deflection of the rubber forming a varying contact area. The wear pattern was highly irregular and a spot of high pressure contact seemed to move erratically. This good low pressure performance confirms the industry choice of soft rubber belt wipers for low pressure wiping.

Figure 37 is a plot of the data for a high density polyethylene blade (position 3, figure 39). This material did not display the dramatic reduction at the critical pressure in the amount of material carried back that the other blade materials showed. This is explained by the low resistance that the HDPE blade had to cutting by the material carried back. The grooves formed by the larger particles allowed passage of the fines.

The results of the second test series (table 2), even though the sampling was extensive (from 2185 square feet of belting), must be tempered with judgments from field observations and the previous tests. These tests were performed with one bulk material on one conveyor within a small range of moisture content. The conclusive results are

1. The critical pressure for scraping is a function of blade contact area, not just width.
2. Even pressure distribution is required over the contact area.
3. The material cleaned from the belting must flow from the blade and blade area.
4. Frictional heat must be dissipated for plastic and elastomeric blades.

5. Backup of the blade contact area is required.
6. Thinner blades with less area require lower total force and horsepower.

TABLE 2. Summary of Amount of Material Carried Back to Blade Pressure for Test Series 2

Blade Pressure (psi)	Amount of Material Carried Back (grams/foot ²)			
	Urethane Blade (92A Durometer)	Carbide Blade	High-Density Polyethylene Blade (98A Durometer)	Rubber Blade (68A Durometer)
0	60.0	60.0	60.0	60.0
5	41.0	36.9	37.6	39.9
10	34.8	33.2	38.0	29.5
15	27.0	29.5	36.0	22.1
20	14.8	22.7	29.8	8.8
25	5.4	12.6	25.1	6.2
30	1.9	8.9	25.2	5.0
35	1.2	5.7	22.4	3.4
40	0.9	1.4	17.7	3.0

Section 6

ANALYSIS OF COMMERCIALY AVAILABLE BELT CLEANERS

6.1 Hardware

In this section, basic belt cleaners as well as some of the special action types are illustrated, and excerpts from sales literature are presented to explain design and installation procedures. Notably, only one manufacturer defined maintenance procedures. The most important point in analyzing the designs is to determine the ability of the mechanism to maintain contact with the belting surface at an even pressure distributed across the contact area.

Single-blade cleaners are simple and effective wipers for removing heavy clinging loads until wear on the blade causes areas of noncontact (figure 6). They are useful as rough cleaners. The standard single blade cleaner uses a counterweight and leverage to maintain pressure on the blade. Care in selecting the blade material is necessary so that abrasive material does not become imbedded, accelerating wear on the belt cover. The unit shown in figure 44 is typical of those commercially available and represents many shop-made belt cleaners of this type.

Lopper blades are another popular cleaner used for rough cleaning. They have an advantage in that they return the cleaned material closer to the material's path (figure 45). However, they are also subject to uneven wear patterns. The commercial unit in figure 46 and the shop-made unit in figure 47 are typical of this type. Both have excellent maintenance features. The commercial unit features blade replacement while the belt is running. The shop-made unit has a drop-in blade that can be changed quickly. Operators of lopper blade systems have expressed some concern over the possibility that a piece of scrap could become wedged between the lopper blade and the belt, thus causing damage to the belting.

Multiple-blade wipers are a variation on the single-blade types. They gain gross effectiveness by performing the same cleaning action more often although individually less effectively. Simple spring-loaded units are low in initial cost, but downtime and maintenance cost are high because they require more frequent adjustment and trimming to keep the blades in contact with the belting. To remove fasteners and replace a blade, a work platform under the conveyor is required. Counterweighted multiblade wipers (figure 48) are more elaborate since they attempt to distribute the force and wear over the blades. This can be a problem because the supports for the blade can contact and damage the belting cover if blade wear is uneven. Another problem is collecting the dribble and returning it to the transport stream. This problem is compounded by a snubbed head pulley arrangement.

The wiper shown in figure 49 has the advantage of an extended wear time over the average straight blade. It has disadvantages in that it exhibits uneven wear patterns and tends to bounce and lose contact with the belting when relatively large grains of material get between the wiper blocks and the belt. Because each block is attached separately, replacement of one block keeps the remaining blocks out of contact with the belting.

Of the belt cleaner mechanisms reviewed, those that wipe the belt with a cross blade in an attempt to maintain contact on the full width of the belting were least effective in cleaning the center of the belt after wear progressed.

The segmented-blade belt scraper (figure 8) is the best mechanism found for maintaining belt contact while allowing for the differential wear pattern that naturally occurs. The mechanism detailed in figure 50 uses rubber in shear for applying the controlled force to maintain contact. The main advantage of this unit is that servicing is possible while the conveyor is running (figure 28). The major problem with this type of unit is that frequent inspections are required to assure that wear, breakage, or fastener failure does not allow a bare mounting rod to contact the belting and cut the cover. Some of the other designs (figure 49) have the same problem. Installation of these units is fairly straightforward and simple if space is available at the bottom of the head pulley. Figure 18 shows a unit poorly installed in an area difficult to see and service and without a flow path

for the cleaned off material. Figures 51 and 52 show details of two other popular mechanisms that attempt to maintain good contact between the action and the belting. Figure 51 shows a coil spring in torque, and figure 52 exemplifies counterweight loading. On conveyors that have mechanically spliced belting, the counterweight unit is at a disadvantage. The inertia of the weights hamper the blade movement and cause higher impact loadings on the blade and the splice. One problem with all scrapers is splice compatibility, but it can be overcome by inseting the splice plates into the top-cover or using the simple ramps that were developed in this program to lift the blade over the splices.

The rotary-brush belt cleaners made by various manufacturers are of two varieties and are similar in operation. To dislodge the material clinging to the belting, they either use a powered drum with protruding rubber fingers or synthetic bristles to strike the belt surface counter to its travel. The two varieties (figures 53 and 54) are categorized by peripheral speed, with the bristle types running about $500 \pm 20\%$ fpm and the finger type running $1200 \pm 20\%$ fpm for removing the clinging material from the belt. They work best on dry materials but can create a dust problem. On wet material, they tend to clog and cease to be effective, although the finger type is less sensitive to moisture.

Another type of rotary cleaner is the grooved-drum (figure 55). A number of manufacturers employ various groove configurations and drum materials. Essentially, grooved-drum rotary cleaners are as effective as multiple wipers. The major advantage of rotary cleaners is that they put the dribble back into the transport stream (figure 56). Maintenance is the major disadvantage. Wear is accelerated by high speed contact, and the power units and bearings require maintenance due to the dust and abrasive material in the area.

The cross-belt brush cleaner (figure 57) is used for special applications. It equalizes wear on the brush and fits well in 90-degree transfers (figure 58) but not in in-line transfers. Maintenance requirements and dust generation problems preclude the use of brush-type cleaners for most mining applications.

Figure 59 shows a specialized cleaner that is installed far back of the discharge point and would require a collecting conveyor to return the cleaned off material

to the main transport stream. This is usually not practical in mining applications. Adding a collector conveyor would not be justified for most applications.

Pneumatic units (figure 60) that attempt to blow "cling" from the belt are not acceptable in mining applications because they generate dust. Also their operation and maintenance costs are higher than for the more conventional methods.

6.2 Qualitative and Quantitative Field Observations

Nine operations, employing over 400 belt conveyors, were visited during this study. Emphasis was placed on conveyor systems that were considered to exhibit good cleaning with the installed devices but previously had exhibited major operational problems because of spillage carried back on the return belting.

Only one operation used belt cleaners on conveyors with results that could be judged completely satisfactory, and this was on only five conveyor units. On one conveyor that had previously experienced an under-pan collapse due to material buildup, four cleaners were installed in series. This resulted in an extremely clean belt. The multiple unit setup cleaned well under a wide variety of material conditions and seemed to clean the belt best when the material (coal in this case) was wet. Sampling the material clinging to the belting an estimate of approximately one gram per square foot was made. Under wet conditions, the material that is scraped from the belting builds up on the blades and arms must be cleared more often than the normal period of once a week. Because the material fell vertically into a silo, no problems occurred with inundation. This cleaner had been in operation about one month, and it did not indicate any belting wear problems. Belt splices were vulcanized. This belt cleaning problem was cured by brute force, but it did demonstrate that belting can be scraped clean (figure 8).

Visual observation of belt cleaners in operation is at best difficult and the conclusions drawn are highly subjective. When materials are dry, dust obscures any clear viewing of the cleaning action, and under wet conditions, accumulations of the cleanings hide the action. To compound the problem, the cleaning mechanism is usually in the dark recesses of the chute work or cantilevered over a stockpile. Conclusive statements must be tempered with experience, reasoning, and analysis

of the subjective comments of operators and maintenance personnel at an operation.

In general, belt cleaners were not observed to be effective in removing "carry-back" from belting except in rare cases. The operator's classic remark is that "belt cleaners do not work." In almost all cases, this was true, but typically it was not totally the fault of the cleaner's action or design. In addition to poor installations of the equipment, maintenance is usually haphazard at best, and in some cases nonexistent.

In good installations with adequate maintenance, belts are cleaned to the 5 to 10 grams of material per square foot, with elastomer wipers cleaning near the high end and scrapers operating on the lower end of the range. The problem of defining adequate maintenance is the variability and range of the characteristics of the conveyed materials. Local climatic conditions can change the moisture content and the amount of material carried back in minutes. Figures 5 and 10 illustrate the large amount of material that can adhere to the return belting (in the pounds per square foot range). This much material can overload a normally effective cleaning action. Thus, a cleaner that is satisfactory under most conditions can quickly be inundated under extreme conditions. One pound of carried back material per square foot on a 48-inch, 500-fpm conveyor is almost 500 tons per shift. A loading of 1000 grams per square foot was found on a feeder belt that was handling coal with an 11.9-percent moisture content. This loading was built up over a period of time, but it was adhering to the belt with such tenacity that it was returned to the carrying side. The size analysis graph of figure 61 shows the material clinging to this belt was to be 50 percent -400 micron material with a typical size distribution curve. In this unique, extreme situation about 10 percent of the belt load was "carry-back" (approximately 1000 tons per shift).

Another measure of the quality of belt cleaning is the particle size of the material that has been removed from the return strand. From the limited sampling and analysis, a scraping action appears to clean finer materials from the belting than does a wiping action. As an example, the graphs of figures 62 and 63 show materials scraped off a belt that would have material clinging to the belt with a

size distribution similar to the graph of figure 61. The shift of the curve position to the right signifies a concentration of the fines. The graphs of figures 64 and 65 show size distribution curves of material wiped off a belt with material clinging to the belt similar to the graph of figure 66. The shift to the left of the curves signifies a concentration of coarse material. Visual inspection of scraped off and wiped off materials verify this observation. The importance of this point is that wiping allows more potential float dust to carry back than scraping, but the residue after scraping is the extreme fines that can cause health hazards.

The sample analysis indicates that part of the spillage does become airborne dust. The graph of figure 67 should be similar to the graph of figure 62, but because the head pulley was exposed, wind action has blown the fines away, particularly in the -500 micron range. Comparison of the graphs of figures 68 and 69 to the graph of figure 70 show that fines depletion occurred in the 200 micron range because the conveyor sampled was in an enclosed gallery and air velocities were low.

6.3 Economic Considerations

Evaluation of the total cost of commercial belt cleaners considered initial purchase and maintenance as major expenses. It was found that most cleaners take a lot of care just to keep the unit in contact with the belting surface and clear of material buildup.

The costs, tabulated in tables 3 through 6, were estimated by assuming that the hardware has a five-year life with no salvage value. Subjective evaluation of the design and the cleaning action of belt cleaner units was used to estimate the total maintenance time, including travel time for getting to the unit and preparation time to gather tools and spare parts. The downtime estimates relate to the amount of time that the conveyor must be shut down to perform maintenance on the cleaners. This downtime cost is almost impossible to accurately estimate because in simple cases the work can be performed during normally scheduled downtime periods, whereas in extreme cases, an unscheduled plant shutdown is required. In many cases, downtime cost could completely obscure all other cleaner cost.

TABLE 3. Cost Estimates for Bladed Belt Cleaners

Supplier	Type/Model	Purchase Cost (\$)	Installed Cost per Month (\$)	Maintenance Cost per Month (\$)	Total Cost per Month (\$)	Downtime per Month (Hr)	Chute Work Factor*
Jeffrey	Single rubber blade, lever arm counterweight	348	8	97	104	1.1	2
Jeffrey	Dual rubber blade, lever arm counterweight	1,040	19	115	134	1.2	2
Jeffrey	Quad rubber blade, lever arm counterweight	1,895	33	140	173	1.6	3
Martin Engineering	Urethane blade, torsion arm loaded	1,419	27	155	183	0.1	2
Lancaster Steel	Dual rubber blade, spring loaded	645	12	105	117	1.5	1
Senior Conflow	Single rubber blade, spring loaded	433	9	85	94	1.1	1
Conveyor Components	Single rubber blade, spring loaded	432	9	85	94	1.0	1
Mastabar	Single wire brush blade, spring loaded	1,119	19	140	159	1.0	1

*Chute work factor reflects an estimate of the additional expense that would be added to the head end installation cost for a belt cleaner conveyor. A scale from 1 through 10 is used to represent complexity, with 1 being the simplest and easiest to design and install.

TABLE 4. Cost Estimates for Segmented-Blade Belt Cleaners

Supplier	Type/Model	Purchase Cost (\$)	Installed Cost per Month (\$)	Maintenance Cost per Month (\$)	Total Cost per Month (\$)	Downtime per Month (Hr)	Chute Work Factor*
Martin Engineering	Torque arm articulated blade/Model CM	972	21	72	93	0.1	4
Conveyor Components	Spring arm angle blade/Model TAB	691	17	121	138	1.1	3
R. J. Dick	Counterweighted stiff arms are double bladed	781	18	121	139	1.1	4
Trelleborg	Counterweighted angle blade wiper	739	17	121	138	1.3	4
Bonded Scale	Spring arm angle blade	498	14	121	135	1.1	3

*Chute work factor reflects an estimate of the additional expense that would be added to the head end installation cost for a belt cleaner conveyor. A scale from 1 through 10 is used to represent complexity, with 1 being the simplest and easiest to design and install.

TABLE 5. Cost Estimates for Specialized Belt Cleaners

Supplier	Type/Model	Purchase Cost (\$)	Installed Cost per Month (\$)	Maintenance Cost per Month (\$)	Total Cost per Month (\$)	Downtime per Month (Hr)	Chute Work Factor*
Flex-O-Disc	Rotating flexible disc wiper	3,158	177	54	231	2.6	10
Conveyor Components	Roller	995	**	**	**	**	2
Vibco	Vibrating roller	1,336	**	**	**	**	2
Plastic Techniques	Rotating wiper blade	1,920	**	**	**	**	8
Indiana Steel	Blower, low air pressure fluidic	3,150	**	**	**	**	3
Hydro Sales	High pressure water	30,000 ⁺					
Lubri-Belt	Parting compound	7,275 ⁺	121	483	604	0.2	0

*Chute work factor reflects an estimate of the additional expense that would be added to the head end installation cost for a belt cleaner conveyor. A scale from 1 through 10 is used to represent complexity, with 1 being the simplest and easiest to design and install.

**Insufficient installation data available for estimation.

+Installed.

TABLE 6. Cost Estimates for Powered Cleaners

Supplier	Type/Model	Purchase Cost (\$)	Installed Cost per Month (\$)	Maintenance Cost per Month (\$)	Total Cost per Month (\$)	Downtime per Month (Hr)	Chute Work Factor*
Shaefer	Crossbrush/Model A	2,345	43	166	209	1.5	8 incline 4 90-degree
Materials Control	Rotary brush/Model 99	2,079	39	176	215	1.6	4
Cottrell Conveyor	Rotary plastic wiper/Model 48HM5	2,320	93	261	354	1.5	4
Tip Top Rubber	Rotary rubber wiper	2,551	43	243	288	1.5	4
Jeffrey	Rotary brush	2,792	50	347	397	1.5	4

*Chute work factor reflects an estimate of the additional expense that would be added to the head end installation cost for a belt cleaner conveyor. A scale from 1 through 10 is used to represent complexity, with 1 being the simplest and easiest to design and install.

Estimated chute-work factor reflects the additional expense that would be added to the head end costs of a conveyor to install a belt cleaner. The installed cost can be represented on a complexity scale from 1 through 10, with 1 being the simplest and easiest to design and install. For estimating purposes, costs could be equated to one man-day plus ten percent of the total chute cost without a cleaner for each point on the scale.

One important cost that has not been estimated is the cleaner's potential to cause damage to the belting. It is apparent from field observations that some of the cleaner system hardware has the potential to destroy the belting. An estimate of this potential and its cost is necessary to accurately establish the relative importance of costs associated with belt cleaner system design, maintenance, installation, and failure mode characteristics.

Direct comparison of clean-up costs can only be accurately made on a site-specific installation. For example, clean-up of spillage under a conveyor where a front-end loader can be used (figure 21) has a cost per ton of less than one-tenth of what it would cost where manual clean-up is required. Estimates from operators of large handling systems are one ton per man-day for manual clean-up and ten tons per man-day for clean-up with a small "bob-cat" loader.

By analyzing the figures for the total cost per month in the tables, it is easy to deduce that if labor cost for manual clean-up are \$100 per man-day, most cleaners are economically justified if they reduce the amount of spillage by two tons per month as this will pay for most belt cleaner installations. The capability of a conveyor to create spillage can be generalized by using this example.

Conveyor width = 4 feet

Conveyor speed = 500 fpm

Estimate 2 grams of spillage for each square foot of return belting.

$$\frac{4 \text{ ft} \times 500 \text{ fpm} \times 60 \text{ min/hr} \times 8 \text{ hr/shift} \times 2 \text{ g/ft}^2 \times 2.2 \times 10^{-3} \text{ lb/g}}{2000 \text{ lb/ton}}$$

= 2.12 tons/shift.

Thus, very small reductions in the amount of spillage (2 g/ft²) can economically justify the use of belt cleaners in one shift of manual clean-up per month.

To estimate the operating cost, a method for calculating the power required to run a cleaner must be determined. This power is supplied by the conveyor drive motor through the reducer and belting. An increase in conveyor drive power is required for powerful cleaners as well as the scraper-wiper types. Capital costs are incurred in more motor-drive-train horsepower and increased belt-tension requirements.

$$\text{Cleaner horsepower requirement} = \frac{P \times A \times \mu \times S}{33,000}$$

P = contact pressure in pounds per square inch

A = area of contact in square inches

μ = coefficient of friction

S = belt speed in feet per minute

Typical coefficients of friction for scraper-wiper materials on dry 65A durometer rubber are

Cast urethane = 0.68

Carbide = 0.48

Polyethylene = 0.39

Rubber 65A = 0.93

For a 48-inch wide by 500-fpm belt conveyor using 30-psi contact pressure, the increased drive horsepower would be

Urethane 1/2-inch thick	= $\frac{30 \times 0.5 \times 0.68 \times 48 \times 500}{33,000}$
	= 7.4 + 10% drive loss
	= 8.2 horsepower
Carbide 1/4-inch thick	= $\frac{30 \times 0.25 \times 0.48 \times 48 \times 500}{33,000}$
	= 2.6 + 10% drive loss
	= 2.9 horsepower
Polyethylene 1/2-inch thick	= $\frac{30 \times 0.5 \times 0.39 \times 48 \times 500}{33,000}$
	= 4.3 + 10% drive loss
	= 4.7 horsepower
Rubber 1/2-inch thick	= $\frac{30 \times 0.5 \times 0.93 \times 48 \times 500}{33,000}$
	= 10.1 + 10% drive loss
	= 11.2 horsepower

This horsepower formula may be used for powered cleaners by determining the appropriate coefficient of friction, but another, simpler method should be adequate. The additional conveyor drive horsepower is the power cleaner motor horsepower minus the horsepower to run the cleaner with no belt contact.

The following sample calculation illustrates that efficient belt cleaning is not inexpensive. But compared to the cost of clean-up, it has a significant economic advantage in addition to reducing the hazard exposure of mine personnel.

Sample calculation for cost of cleaning

Clean 48-inch-wide conveyor belt to 1 gram per square foot; conveyor speed, 500 fpm.

1. Urethane lopper blade 12 psi cleaning pressure
2. Carbide scraper 30 psi cleaning pressure
3. Urethane scraper 30 psi cleaning pressure

Unit 1, clean to 50 grams per square foot:

Purchase cost	\$1,419	} from table 3
Installed cost per month	27	
Maintenance per month	<u>155</u>	
Cost per month	\$ 183	

$$\begin{aligned} \text{Horsepower} &= \frac{12 \times 0.5 \times 0.68 \times 48 \times 500}{33,000} \\ &= 2.96 + 10\% \text{ drive loss} \\ &= 3.3 \text{ horsepower} \end{aligned}$$

$$\begin{aligned} \text{Belt tension increase} &= \frac{2.96 \times 33,000}{500 \times 48} \\ &= 4.1 \text{ pounds per inch} \end{aligned}$$

$$\begin{aligned} \text{Power cost/month,} \\ \text{0.05/kWH} &= \frac{3.3 \times 0.746 \times 0.05 \times 175}{0.7 \text{ pf}} \\ &= \$30.77 \text{ per month} \end{aligned}$$

Total estimated cost \$215.00

Unit 2, clean to 10 grams per square foot:

Purchase cost	\$ 691	} from table 4
Installed cost per month	21	
Maintenance cost per month	<u>72</u>	
Cost per month	\$ 93	

$$\text{Horsepower} = \frac{30 \times 0.25 \times 0.48 \times 48 \times 500}{33,000}$$

$$= 2.62 + 10\% \text{ drive loss}$$

$$= 2.9 \text{ horsepower}$$

$$\text{Belt tension increase} = \frac{2.62 \times 33,000}{500 \times 48}$$

$$= 3.6 \text{ pounds per inch}$$

$$\begin{aligned} \text{Power cost/month} \\ \text{at 0.05/kWH} &= \frac{2.9 \times 0.746 \times 0.05 \times 175}{0.7 \text{ pf}} \end{aligned}$$

$$= \$27.04$$

$$\text{Total estimated cost/month} = \$120.00$$

Unit 3, clean to 1 gram per square foot:

Purchase cost	\$ 691	} from table 5
Installed cost per month	21	
Maintenance cost per month	<u>72</u>	
Cost per month	\$ 93	

$$\begin{aligned} \text{Horsepower} &= \frac{30 \times 0.5 \times 0.68 \times 48 \times 500}{33,000} \\ &= 7.42 + 10\% \text{ drive loss} \\ &= 8.2 \text{ horsepower} \end{aligned}$$

$$\begin{aligned} \text{Belt tension increase} &= \frac{7.42 \times 33,000}{500 \times 48} \\ &= 10.2 \text{ pounds per inch} \end{aligned}$$

$$\begin{aligned} \text{Power cost/month} \\ \text{at 0.05/kWH} &= \frac{8.2 \times 0.746 \times 0.05 \times 175}{0.7 \text{ pf}} \\ &= \$76.47 \end{aligned}$$

$$\text{Total estimated cost/month} = \$170.00$$

The total installed, maintenance, and operating cost for the conveyor belt cleaners:

Unit 1	\$215
Unit 2	120
Unit 3	<u>170</u>
Total	\$505

The amount of material removed:

$$\frac{49 \text{ g/ft}^2 \times 4 \text{ ft} \times 500 \text{ ft/min} \times 60 \text{ min/hr}}{28.35 \text{ g/oz} \times 16 \text{ g/lb}} = 12,962 \text{ lb/hr} = 6.48 \text{ tons/hr.}$$

Or about 50 tons/shift x 21.5 shifts/month = 1075 tons/month. The cleaning cost per ton: \$505/month/1075 T/M = \$0.47/ton of carry-back. If even only a fraction of this carried back material fell from the belt and required manual cleanup, it can be easily seen that belt cleaners offer order of magnitude savings as compared to \$100/ton manual cleanup.

The real cost comparison that should be made is to define the difference in the quantity of spillage before and after cleaning. The amount of spillage will also vary as a function of the conveyor length. More accurately, the spillage varies with the number and type of return idlers in contact with the return strand. The return idler can be considered a belt cleaning device that removes the material sticking to the belt by a combination of wringing, wiping, and surface adhesion (figure 20). Their effectiveness as a cleaner varies with idler drag, friction of the roller material, and belting surface contact. A disc type of return idler (figure 71) that is in contact with half the belt surface would have 50 percent less fall-off under the same conditions.

In a belt cleaning system, the desired result is the elimination of spillage. The gross amount should relate to gross "carry-back" modified by a spillage factor of the return strand machinery. The relationship is

$$\begin{aligned}
 FO_t &= \text{total spillage} \\
 &= \sum_{n=1}^N FO_n \\
 FO_n &= \text{spillage at each return idler} \\
 &= CB_{n-1} F_c \\
 F_c &= \text{spillage factor} \\
 CB_{n-1} &= \text{material clinging to the belting at each return idler} \\
 n &= \text{the } n\text{-th return roll} \\
 N &= \text{total number of return rolls}
 \end{aligned}$$

This relationship indicates that the amount of material clinging to the conveyor belting is removed as spillage over the length of the conveyor, primarily by the action of the return idlers. Each idler removes less material than the preceding idler, but the total spillage is incrementally increased by each idler. Therefore, the total spillage is a function of the material clinging to the belting, the spillage factor, and the number of idlers. For a design engineer to evaluate the economics and make a hazard analysis to support the selection of a belt cleaner system for each specific conveyor, a method of solving this relationship is necessary, at least

in some empirical form, since it determines the amount of spillage that will need to be handled.

Using the average spillage per idler, an F_c of 0.05 ± 0.01 covered 75 percent of the data in the series 1 tests. This is site-specific with some control of the material but with wide moisture variations. Characteristics of the spillage are also an important factor in developing methods of capturing and disposing of the material to reduce the hazard of cleaning up spillage.

Section 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

It is evident from the results of this investigation that the return strand of a belt conveyor can be cleaned of materials to a lower limit of 1 gram per square foot of belting. It is also evident it is not inexpensive or simple to accomplish but would be cost-effective with a bonus of greatly reducing the exposure to hazard of the miner. At this point in time, commercially available belt cleaners can clean the belt to the 5- to 10-grams per square foot range if the material is wetted prior to cleaning to obtain the necessary cooling and flow properties.

The material that clings to the return belting is finer and has a higher moisture content than the load material. Cleaning actions further modify these characteristics, making the residual material even finer and wetter. After removal by a cleaning device, the material presents serious capture, handling, and disposal problems. The removed materials are sticky, have high sliding and internal friction angles, and become airborne when dry.

The controlling factor in the effective removal of material from the return strand of conveyor belting is the pressure on the cleaner blade. Previous research and investigations grossly underestimated the pressure required for effective cleaning.

The effectiveness of belt cleaner blades is controlled by the interaction of "carry-back" and the blade material. Blade material must be immune from cutting by the carry-back particles. This can be accomplished with both elastic or hard materials. High pressure scraper blades can be applied to belts with mechanical splice by incorporating ramps on the blades to lift the blade over the splice similar to the type developed in this program.

7.2 Recommendations

The results of this research show that sharp reductions can be made in the amount of carry-back spillage by the use of belt scrapers. Safety is enhanced and the economics are highly favorable. The amount of material carried back on the belt can be reduced to less than 10 grams per square foot by the proper application, installation, and maintenance of state-of-the-art, commercially available cleaning devices. In light of the safety and economic penalties that accompany the cleanup of carried-back material, it would benefit manufacturers, A&E concerns, and mine operators alike to provide, in the initial design of conveyor systems, for the application of effective, maintainable belt cleaners to minimize the amount of material that needs to be rehandled.

The research also shows a gap in the fundamental understanding in the physical phenomena of belt wiping and scraping and the mechanism that causes material that clings to the belting to come off as spillage. The fact that material clinging to the belting has different characteristics than the load material and is further modified by the act of belt cleaning should be documented to establish what effect this has on the material, belt, and idler interaction that causes spillage.

This research has defined the difference between wiping and scraping to be a function of the contact pressure. The pressure for effective cleaning is considerably higher than formerly perceived. The higher pressure alters the criticality of factors influencing cost and maintenance. The effects on wear are undefined. When wiping, the blade material is in contact with abrasive carry-back; when scraping, the contact is primarily with the belt cover. Scraping may have the potential to decrease cover and blade wear even at higher pressures because of this effect. Power requirements need better definition and the effects that thermal degradation has on some of the elastomeric blade materials at the higher operating pressures warrants investigation.

Most of the effort expended in the laboratory test phase was used to control the material flow in the recycle system. By the nature of the material needed for the tests, it is the most difficult to handle and control, particularly in the small quantities and feeds required for laboratory testing. Additional laboratory evaluation is recommended.

Considerable attention should be given to determining and evaluating the factors that influence critical scraping pressure. Material characteristics, belt speed, and blade material and angle appear to have the most influence. Most likely the cling material and blade material compatibility will be the hardest to understand. Effects and reactions at the belt-blade interface as a function of particle size require detailed evaluation.

The above observations represent important considerations in the design and operation of experiments to reasonably simulate field conditions and permit quantitative assessment of significant parameters.

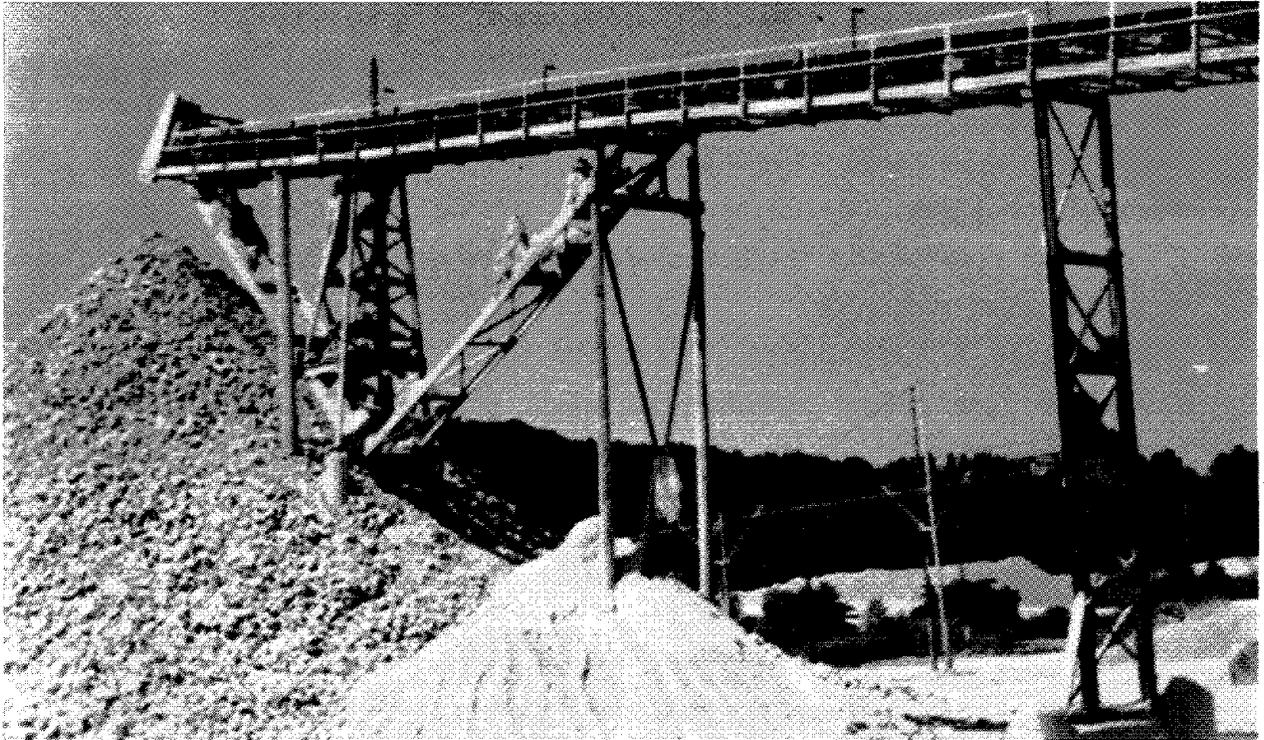


Figure 1. Surge Pile Conveyor

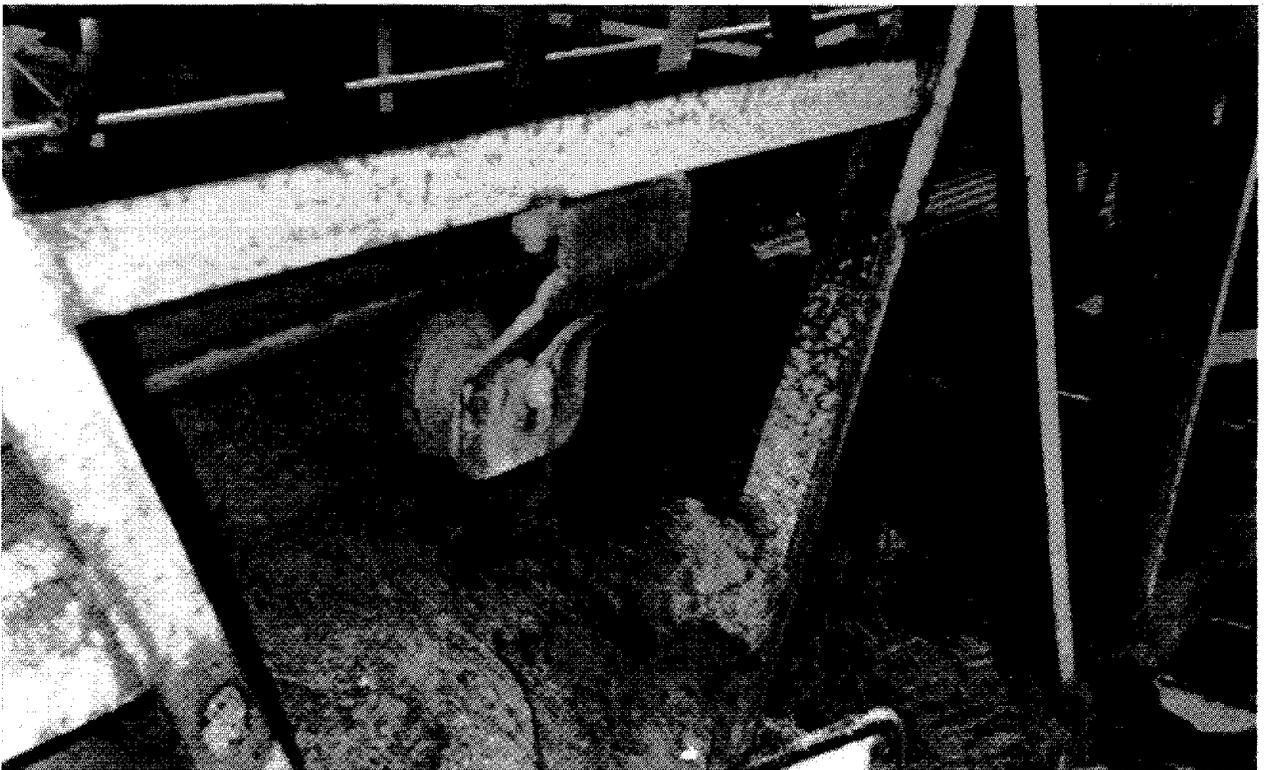


Figure 2. Return Roll Covered With Spillage

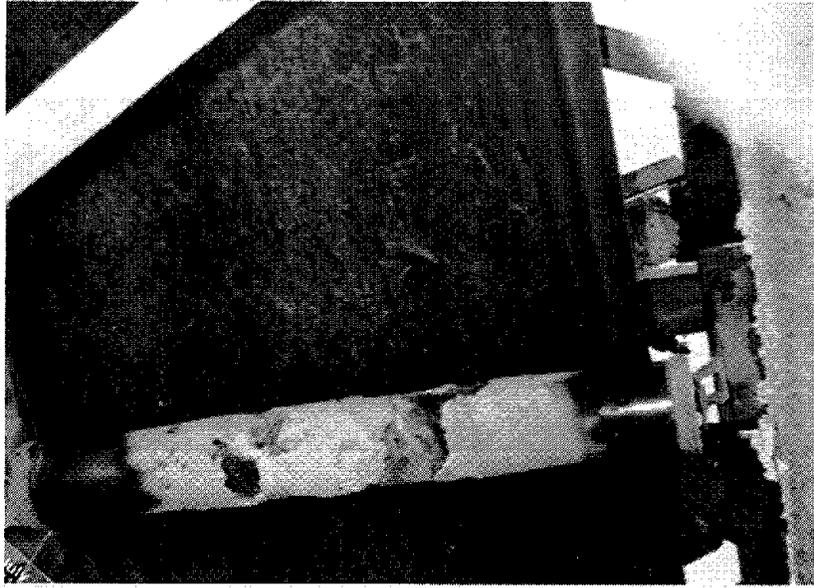


Figure 3. Buildup of Material on Idler

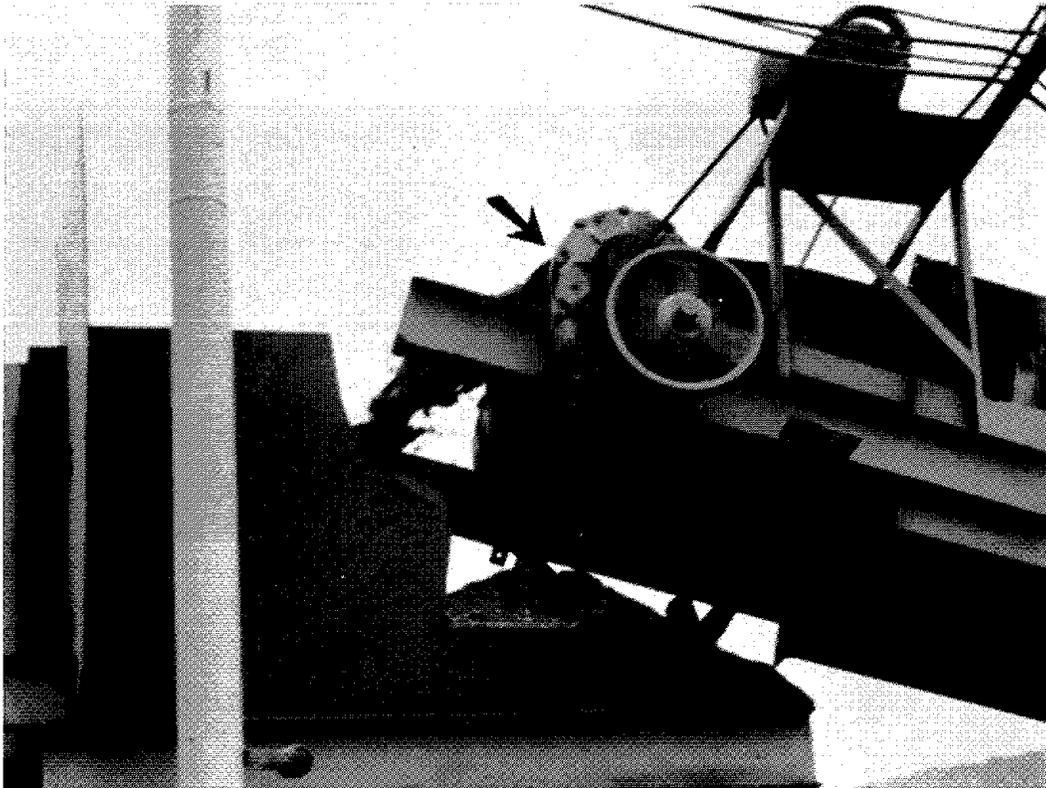


Figure 4. Head-End Discharge



Figure 5. Close-Up View of Head-End Discharge



Figure 6. Lopper Blade

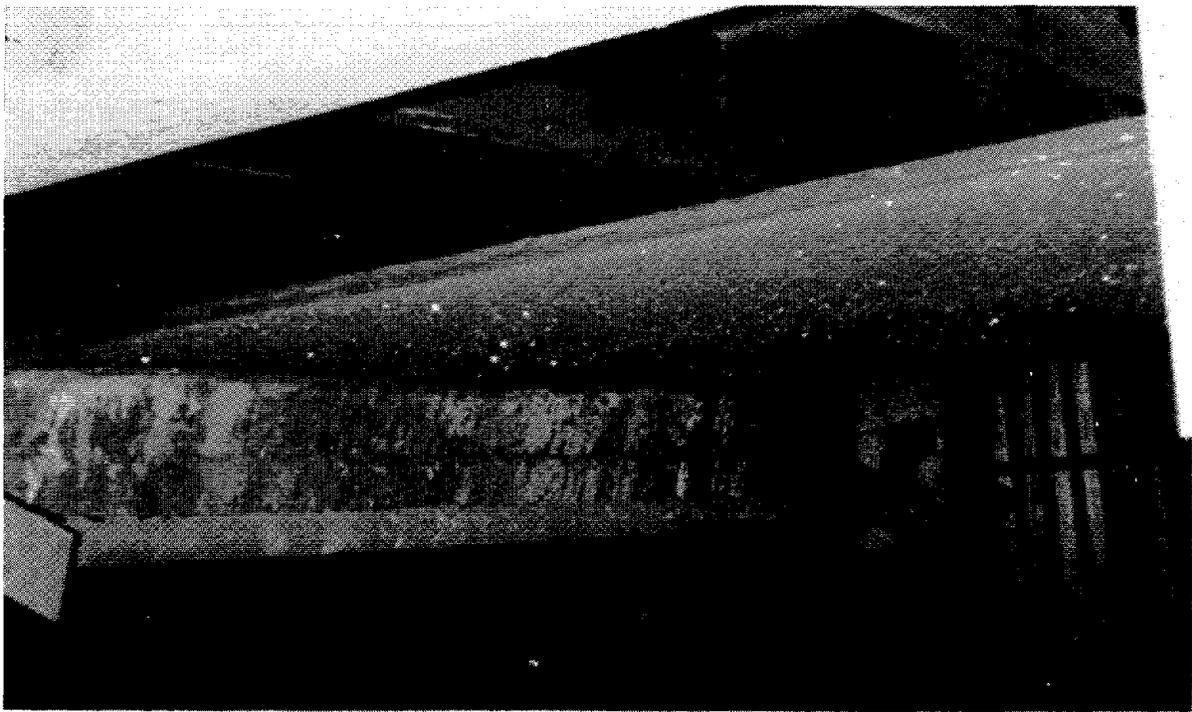


Figure 7. Single Blade Wiper

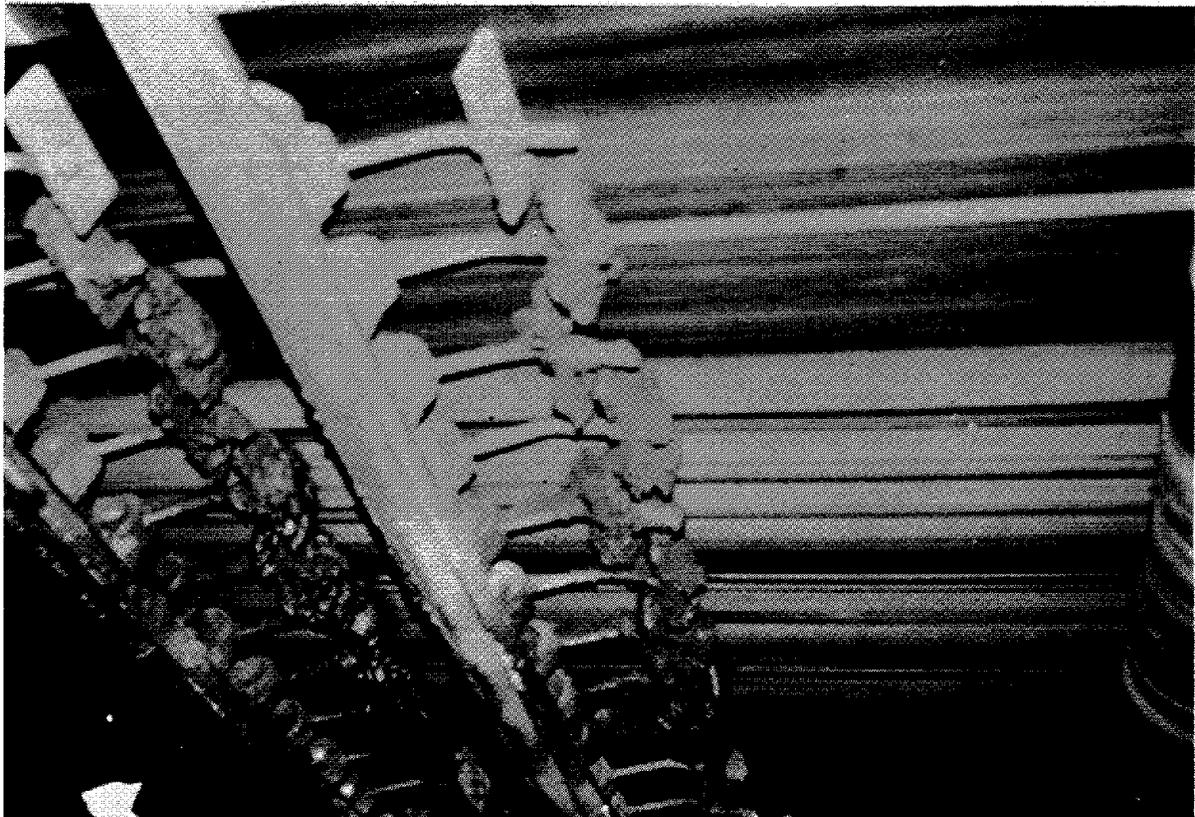


Figure 8. Segmented Scrapers



Figure 9. Rotary Belt Brush

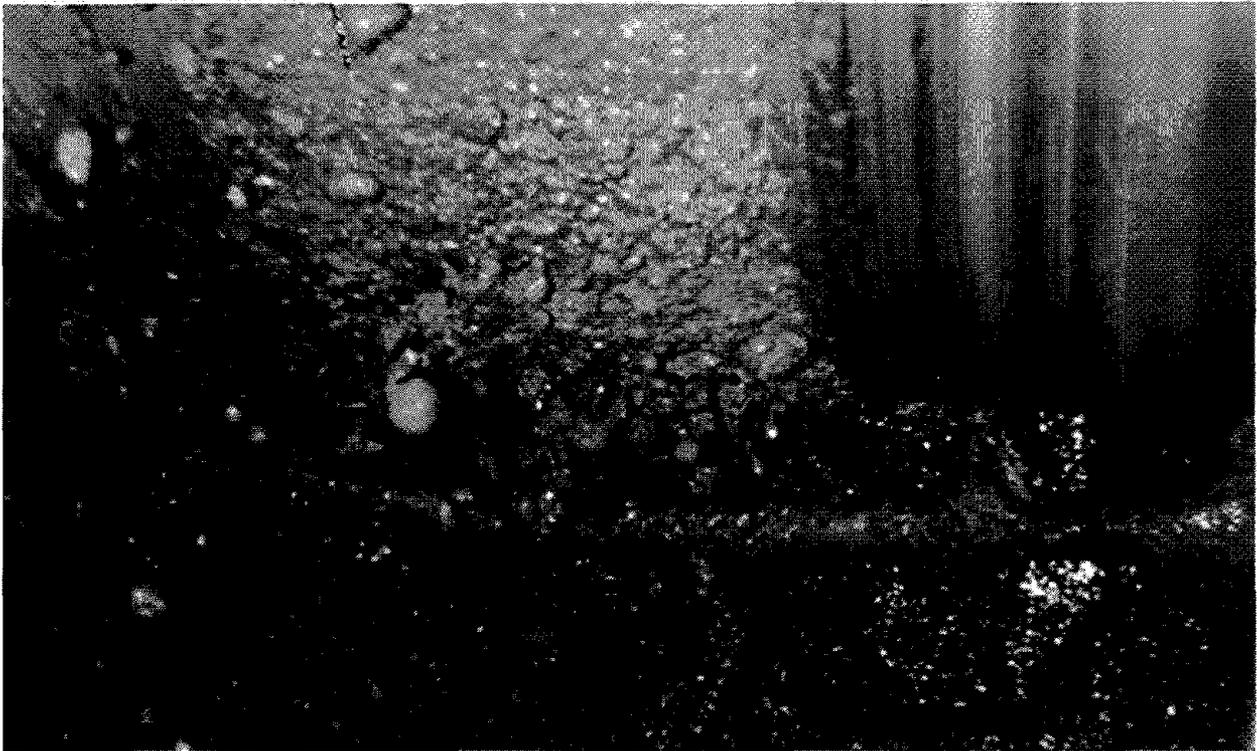


Figure 10. Belt Washer

Figure 11. Illustration of Wringing Action

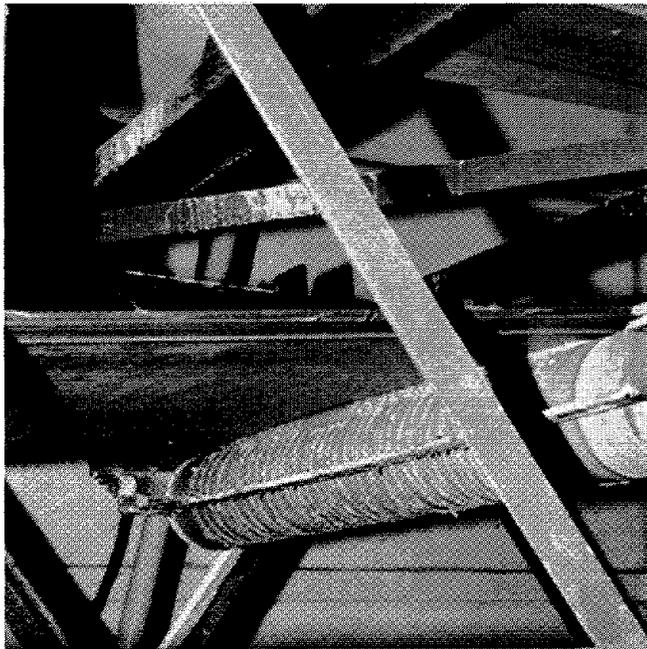


Figure 12. Fixed-Blade Wiper

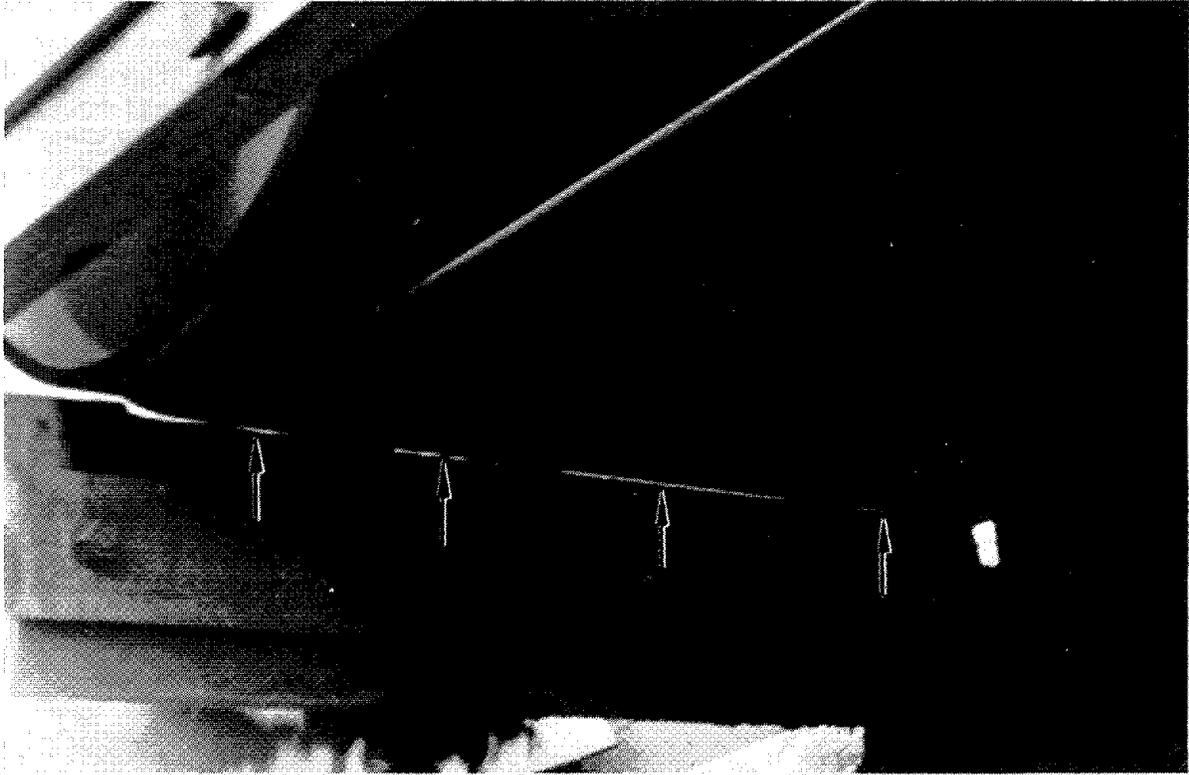


Figure 13. Wiper Wear Pattern

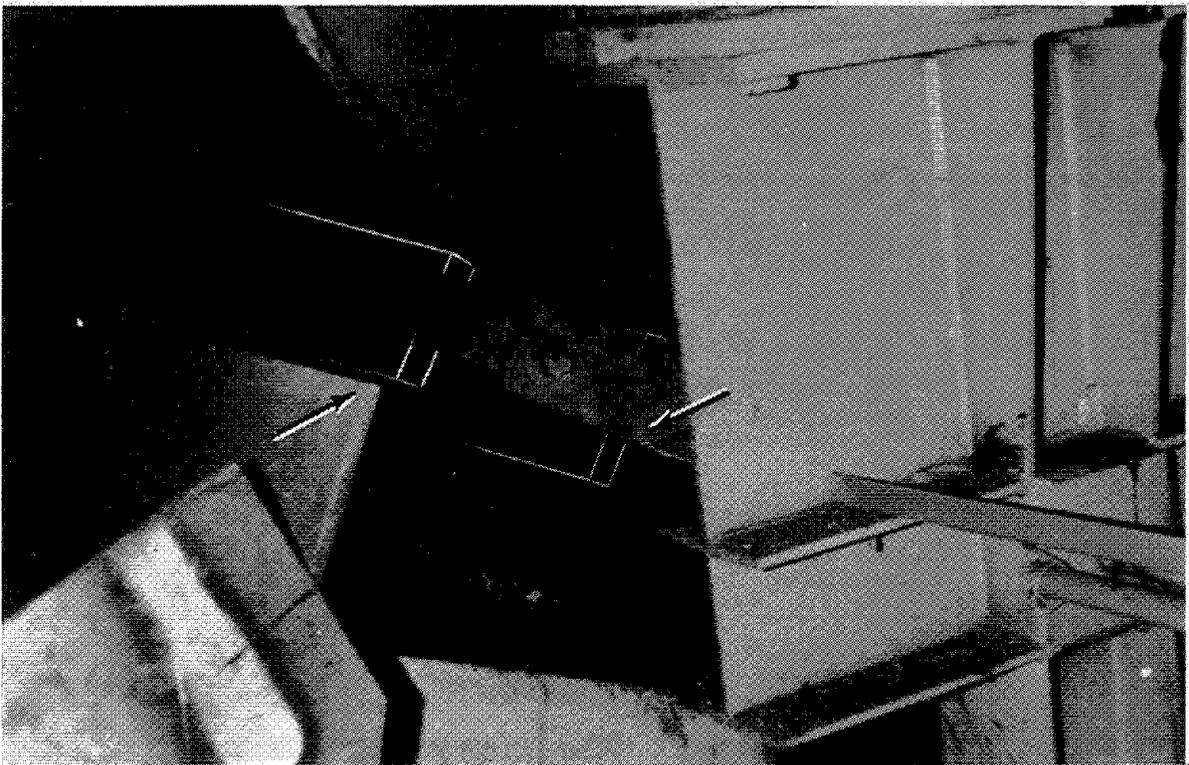


Figure 14. Multiblade Wiper

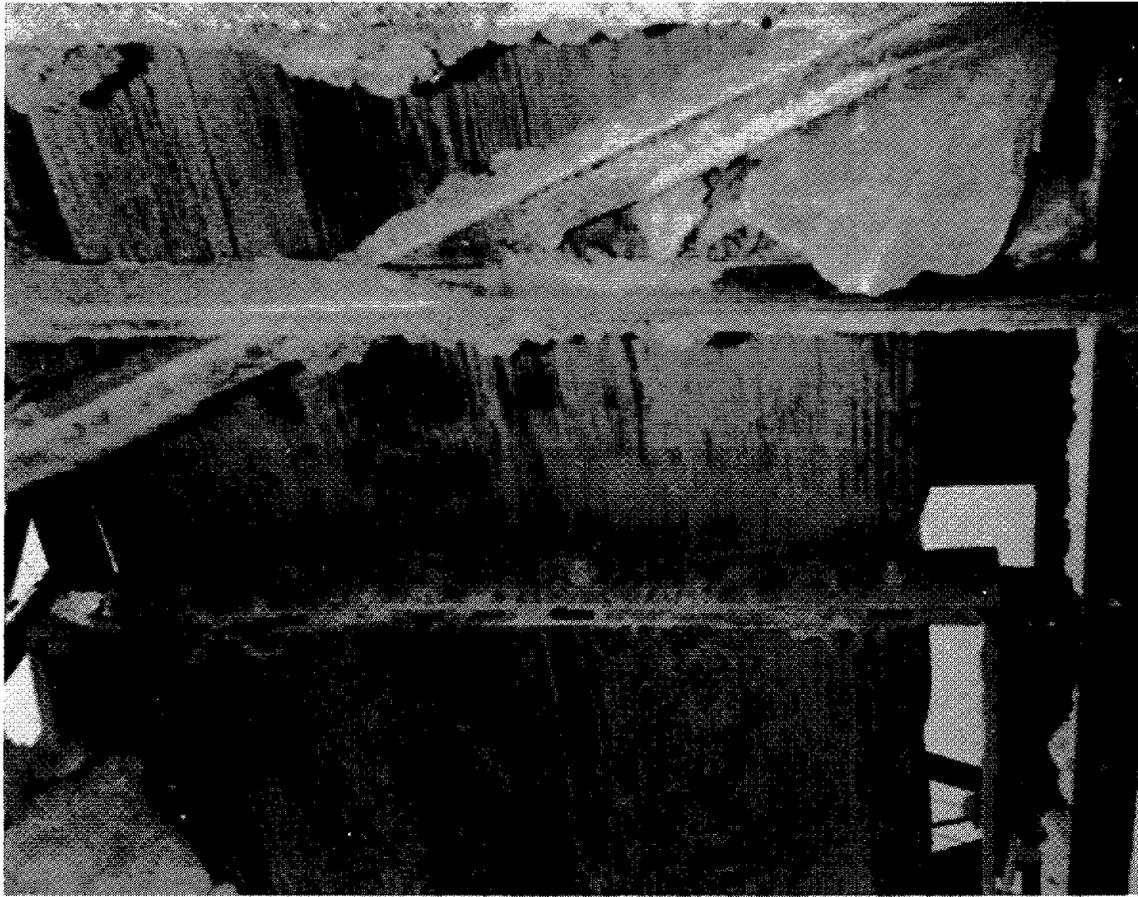


Figure 15. Carried-Back Material Passed by Wiper



Figure 16. Spillage Behind Wiper

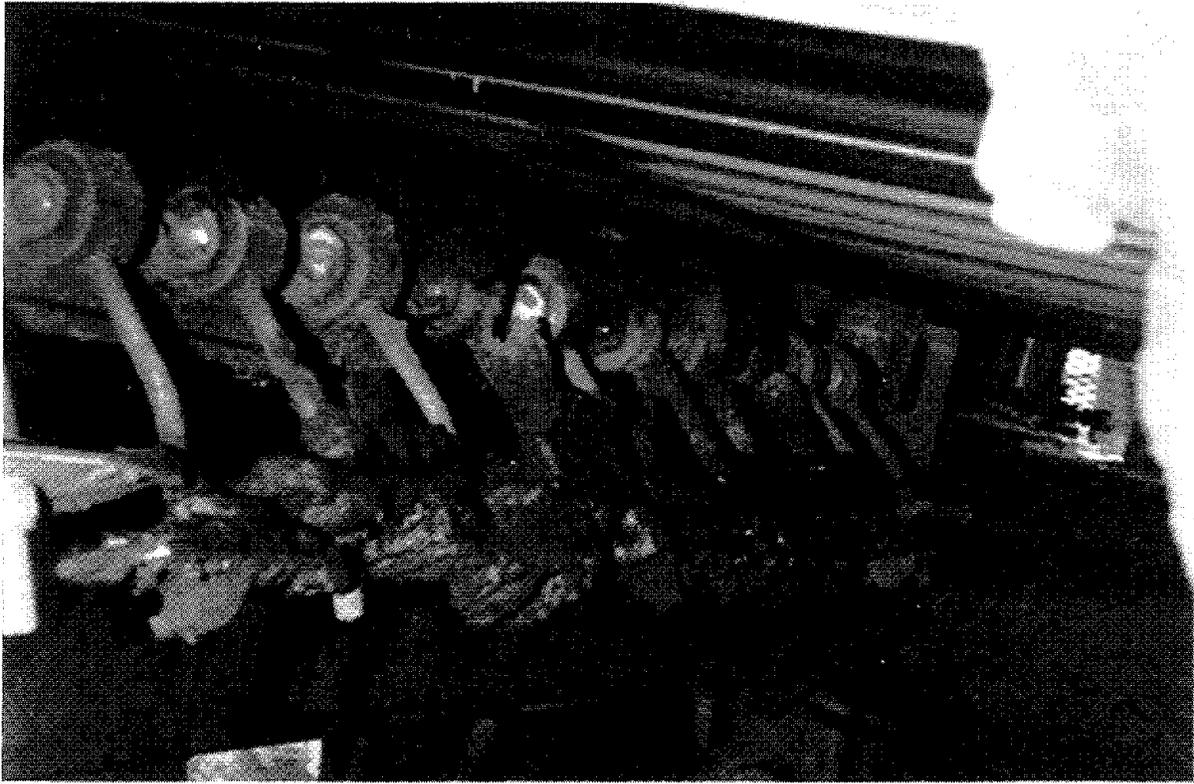


Figure 17. Material Buildup on Scraper

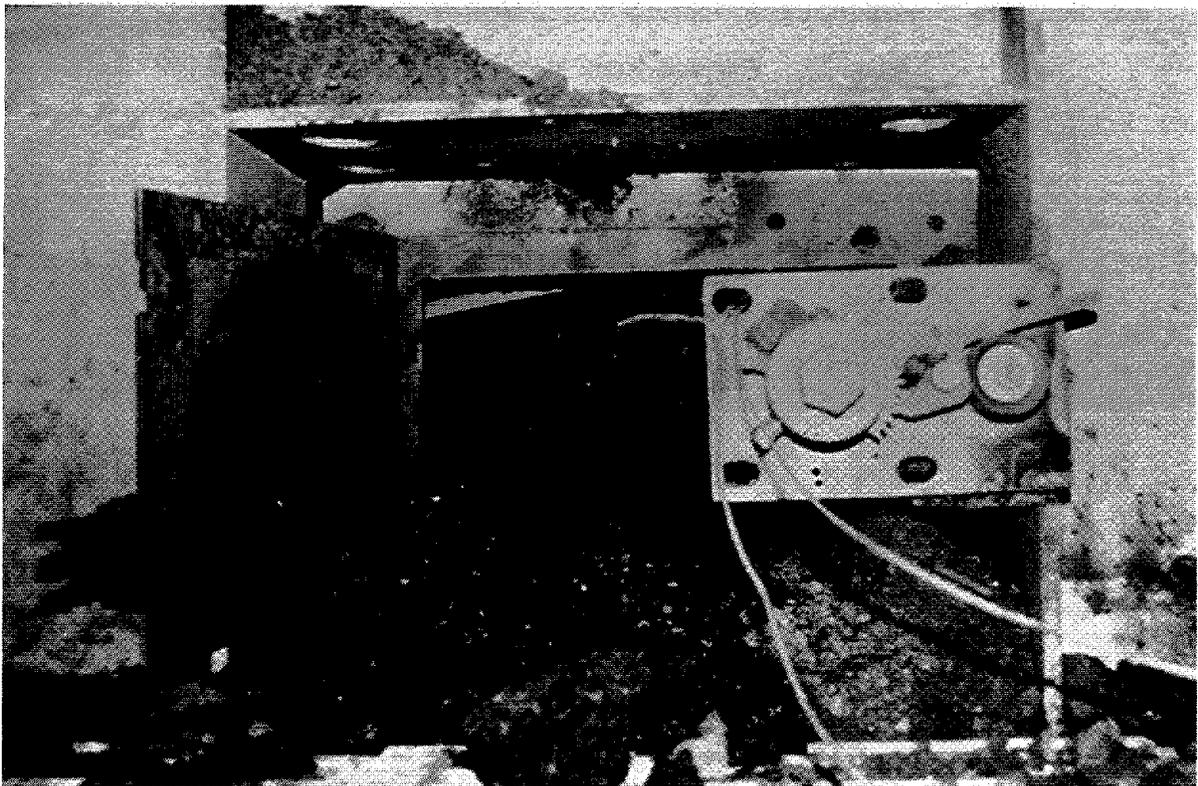


Figure 18. Buried Scraper

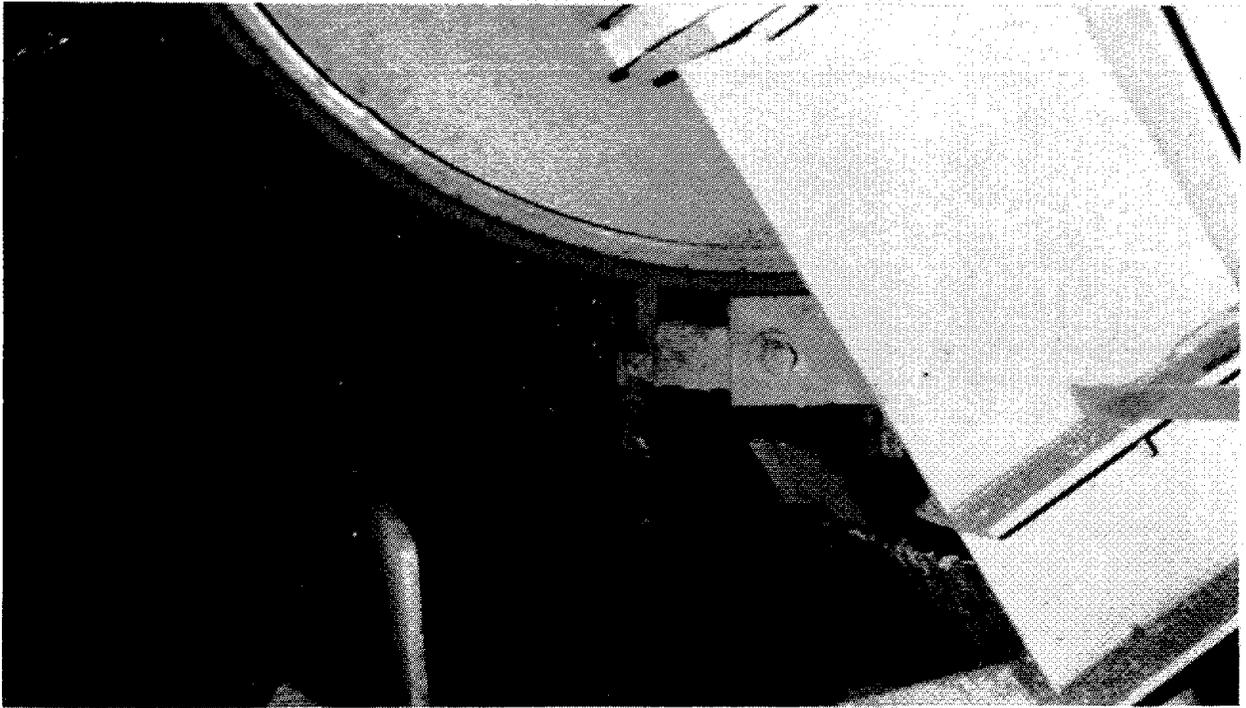


Figure 19. Poor Wiper Placement Due to Inadequate Space Around Head Pulley

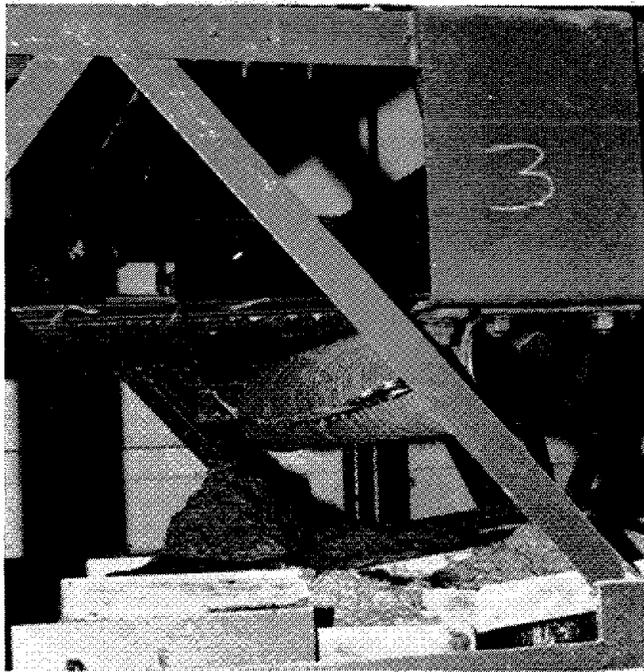


Figure 20. Material Buildup on Idler



Figure 21. Accumulation of Spillage



Figure 22. Wiper Deflection



Figure 23. Idler End-Bell Wear



Figure 24. . Buildup of Material on Bend Pulley

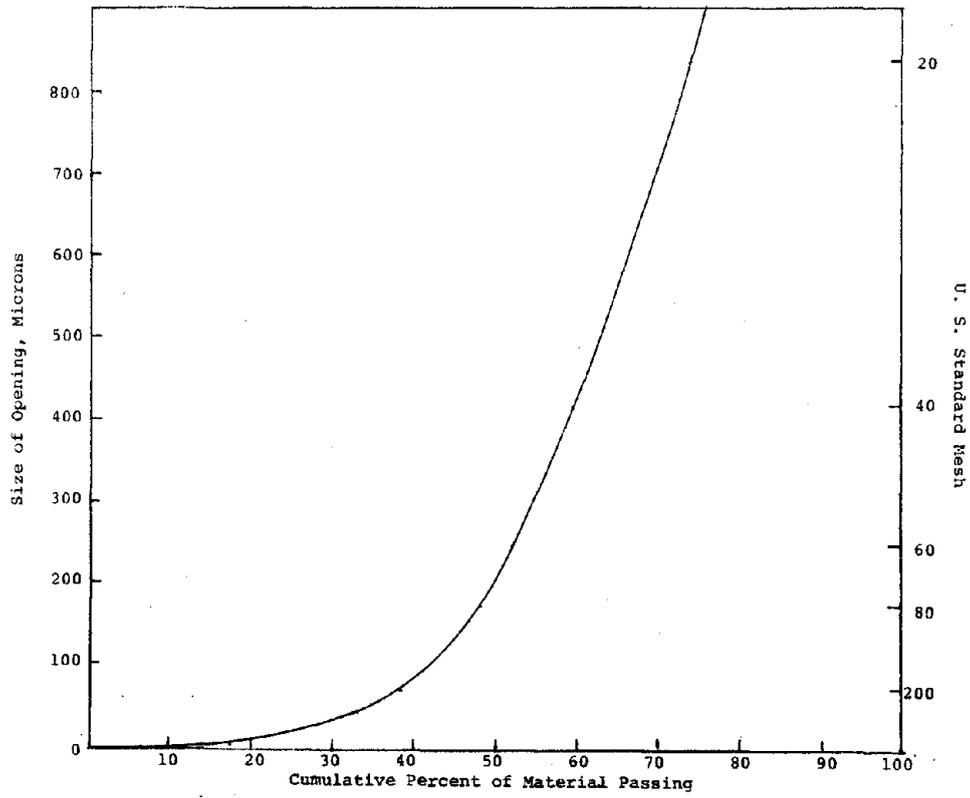


Figure 25. Screen Analysis; Material - Sand

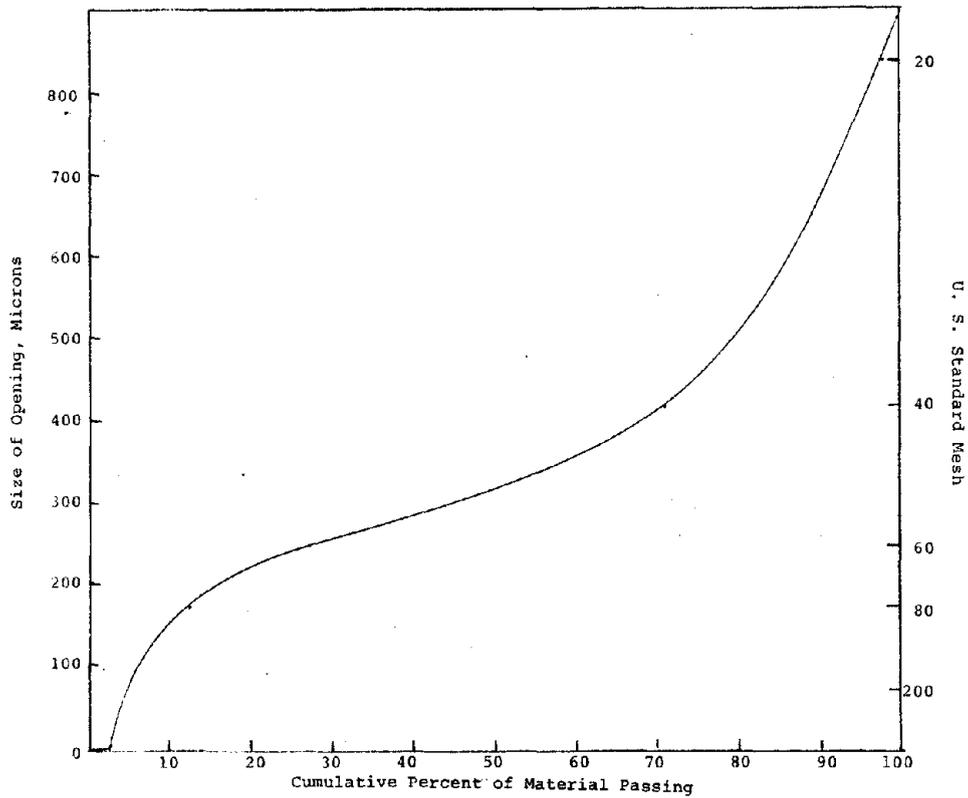
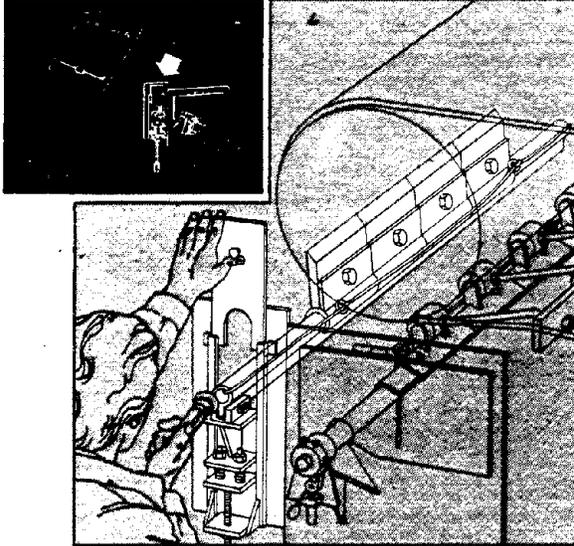


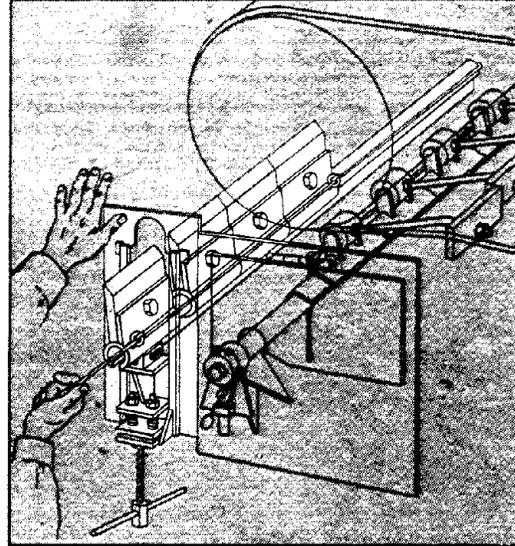
Figure 26. Screen Analysis; Material - Sand

How to service the Doctor blade IN A MARTIN TRAC-MOUNT® SYSTEM

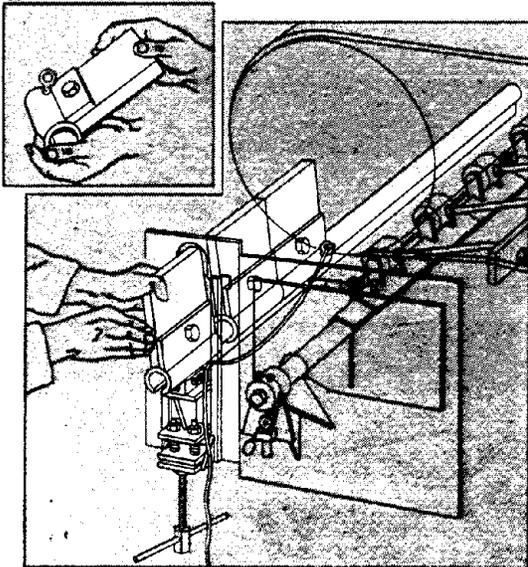
CAUTION! Do not reach inside of chute under any circumstances with belt running.



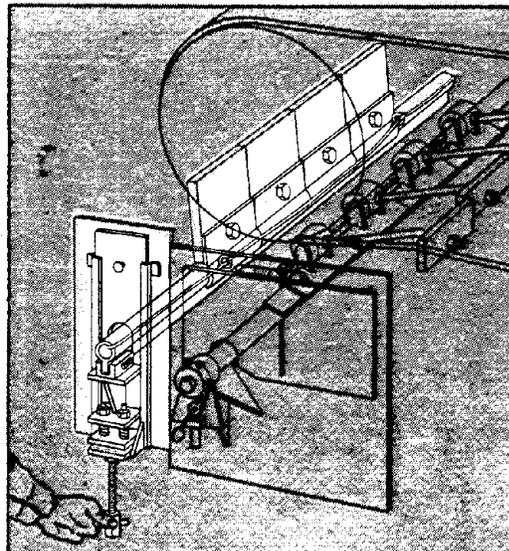
1 Remove window cover. Check general appearance of blades for build-up and wear. Use a flashlight if necessary.



2 If blades are worn out or damaged, lower blades away from belt by turning the jack screw. Pull on lanyard cable to slide blade carriers on their track through the window.



3 Remove blade segments. Clean the reusable segments. Unbolt and replace the worn. Reassemble segments and slide them back into conveyor.

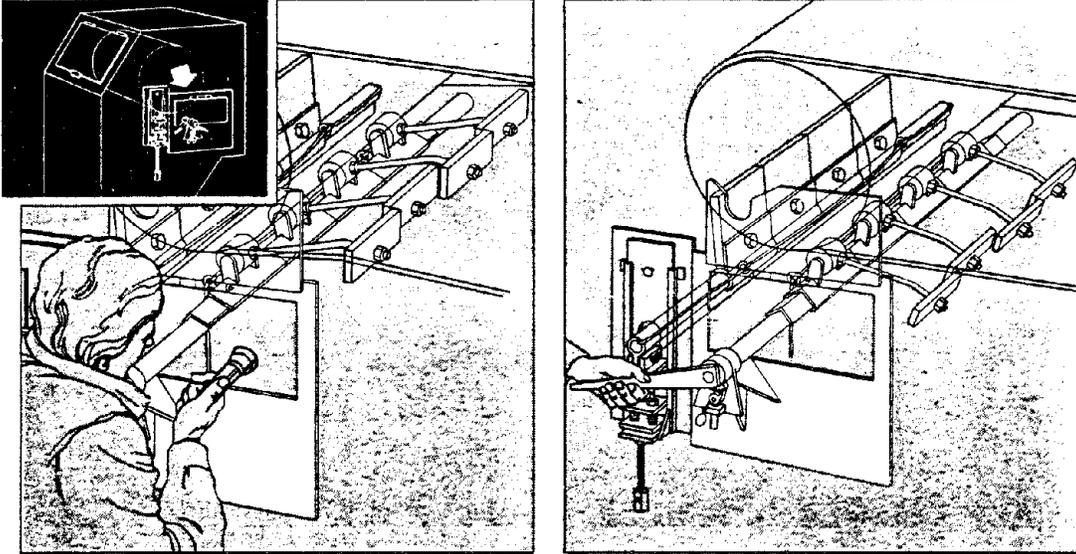


4 Reposition blade to belt by tightening the jack screw. Use light pressure until blade seats itself into belt. Be careful not to over-tighten. Replace window cover.

Figure 27. Lopper, Martin

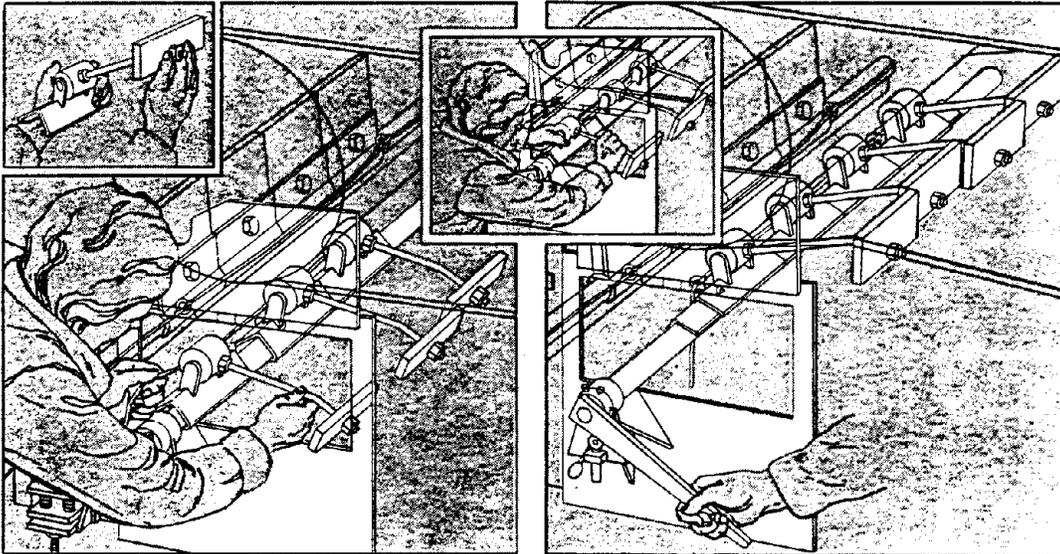
How to service the Torsion Arm® cleaner IN A MARTIN TRAC-MOUNT® SYSTEM

CAUTION! Do not reach inside of chute under any circumstances with belt running.



1 Raise the access door. Check appearance of individual arms for build-up, wear and adjustment. Use a flashlight if necessary.

2 Before servicing, turn ratchet handle to swing arms away from belt and swing back sharply to rap blades against belt to knock off built-up material.



3 Remove arms. Clean the reusable arm blades. Unbolt and replace the worm. Slide arms back on track and push them under conveyor.

4 Reposition arms to belt and re-tension with the ratchet handle. Use just enough pressure to clean the belt. Do not over-tighten. Close door.

NOTE: Steps 1 and 2 should be performed periodically as a part of routine preventive maintenance.

For additional assistance use our Free Flow Line 800-447-5681 or (309) 594-2384.

Figure 28. Segmented Scraper, Martin

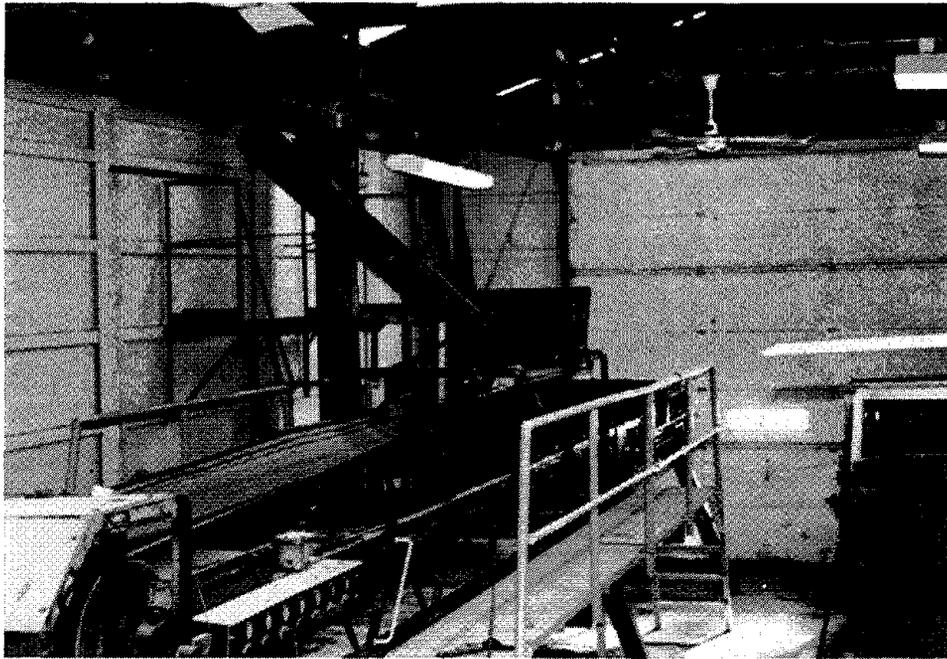


Figure 29. Thirty-Six-Inch Test Conveyor

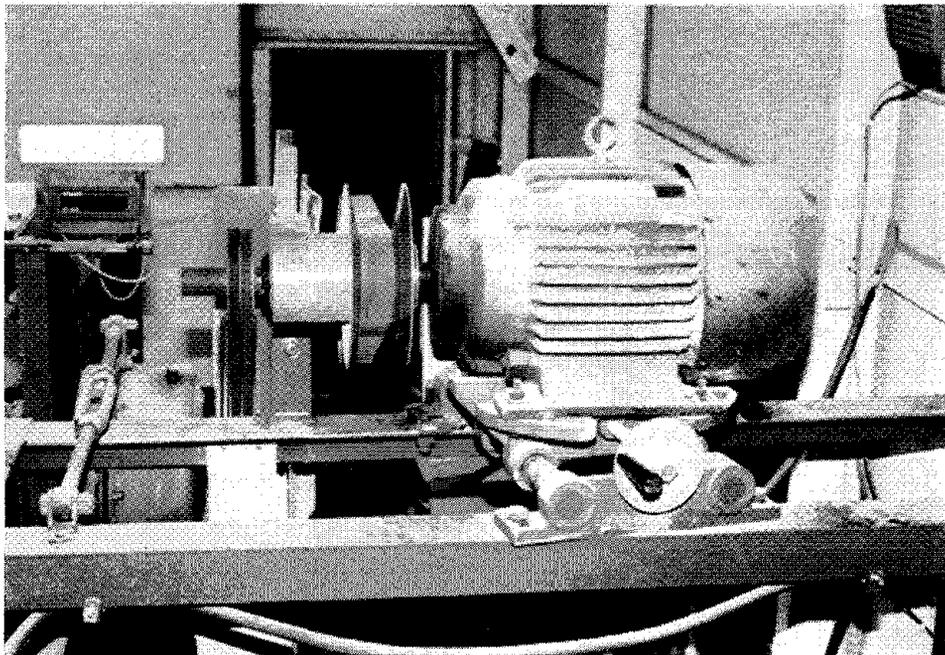


Figure 30. Variable-Speed Drive

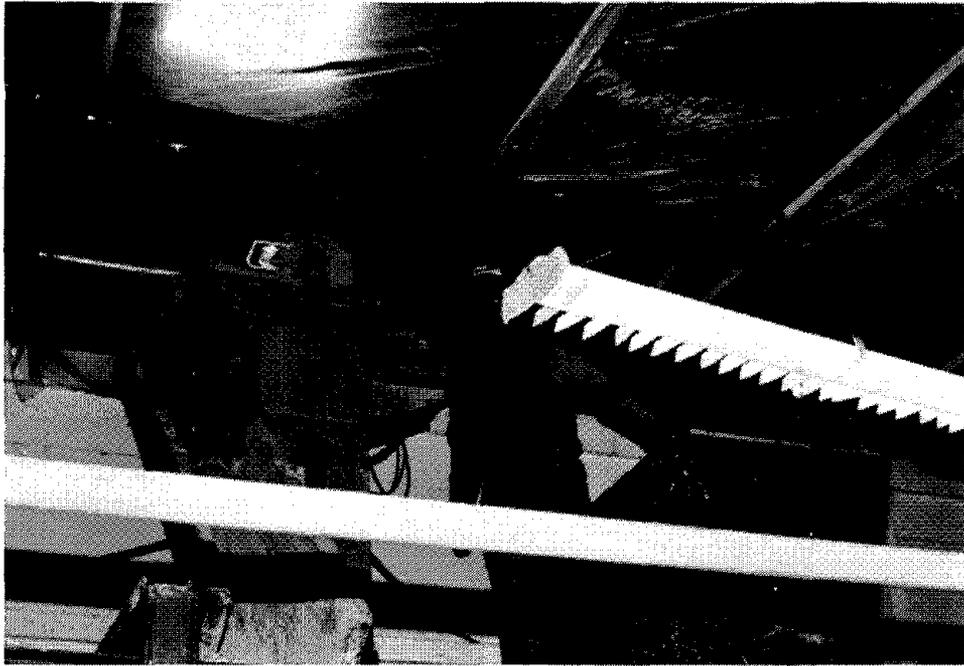


Figure 31. Six-Inch Belt Bucket Elevator

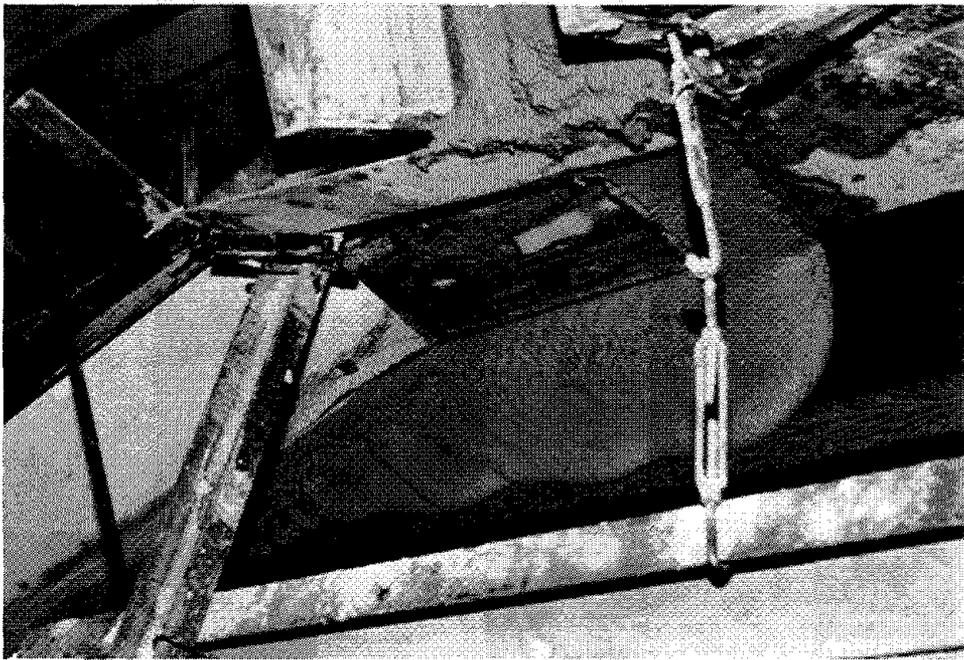


Figure 32. Chute Discharge and Spreader

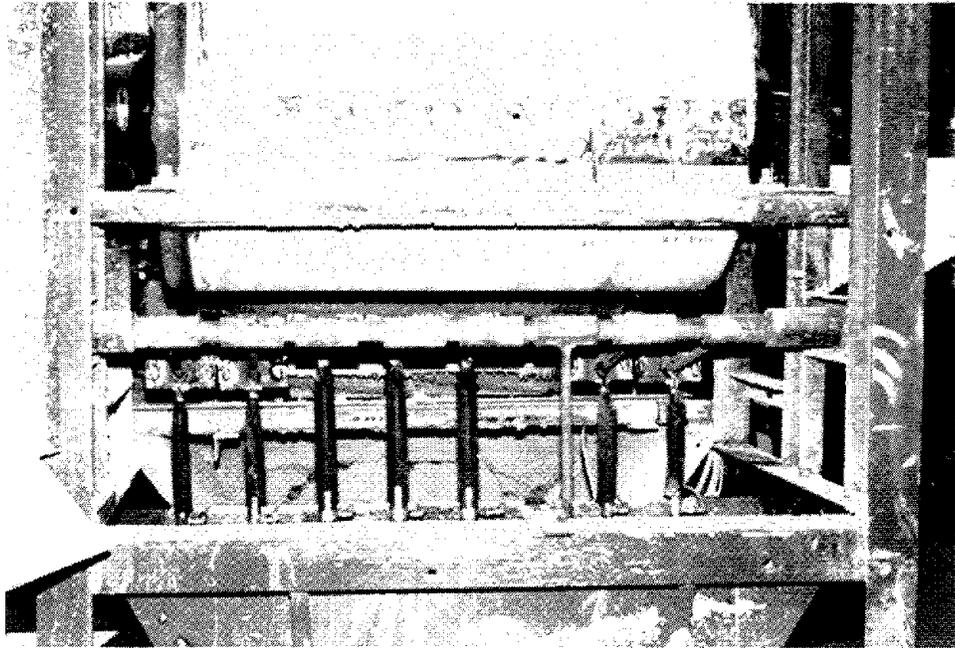


Figure 33. Installed Test Action

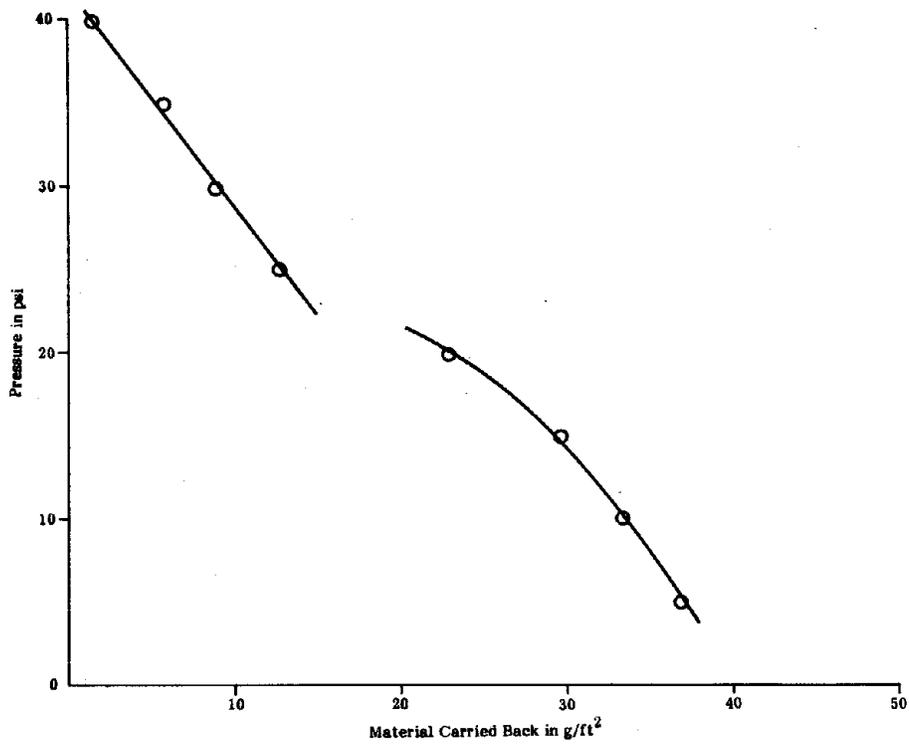


Figure 34. Comparison of Load Carried Back to Pressure on a Carbide Blade

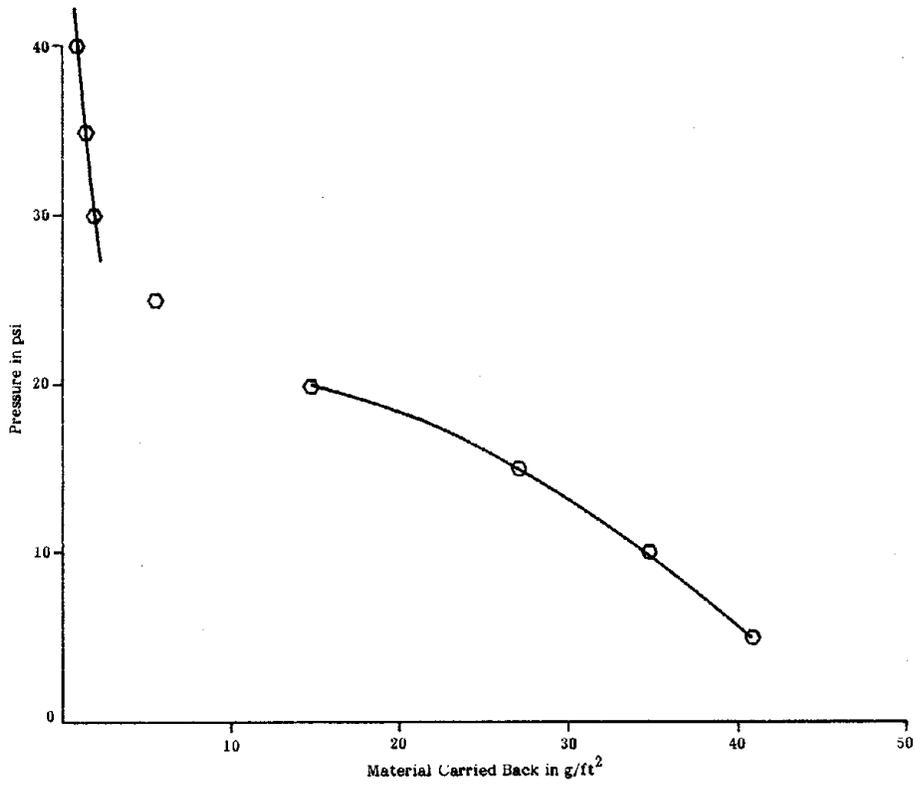


Figure 35. Comparison of Load Carried Back to Pressure on a Urethane Blade (92A Durometer)

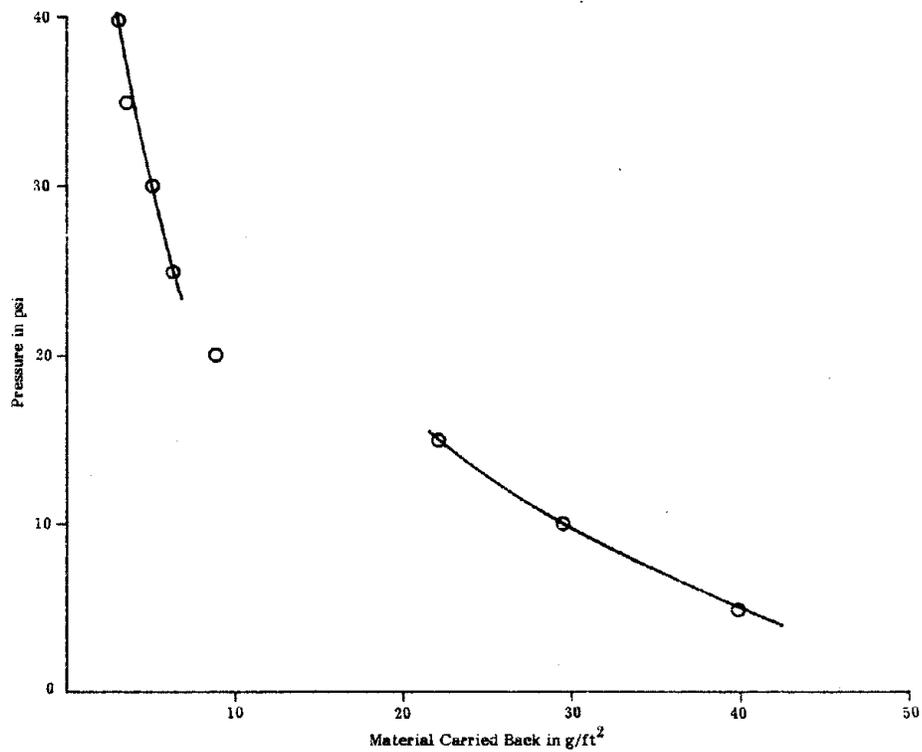


Figure 36. Comparison of Load Carried Back to Pressure on a Rubber Blade (65A Durometer)

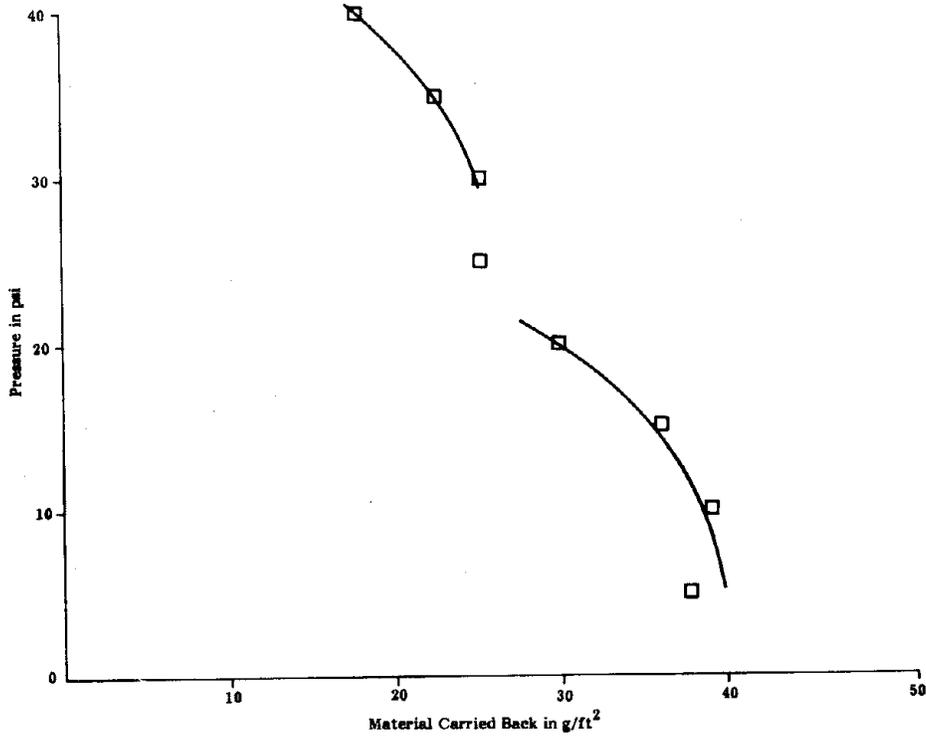


Figure 37. Comparison of Load Carried Back to Pressure on a High Density Polyethylene Blade (68A Durometer)

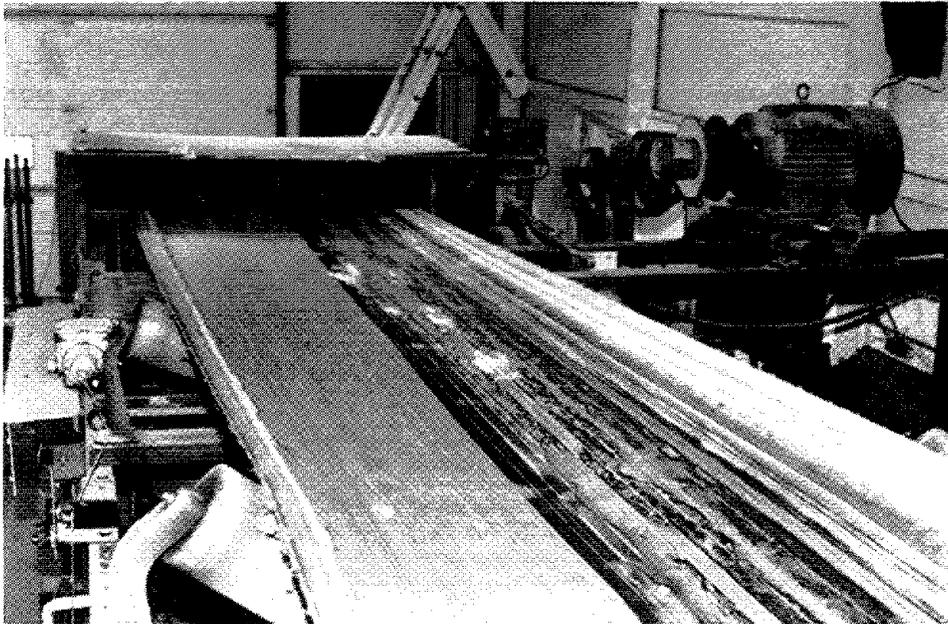


Figure 38. Comparative Cleaner Test, Series 1

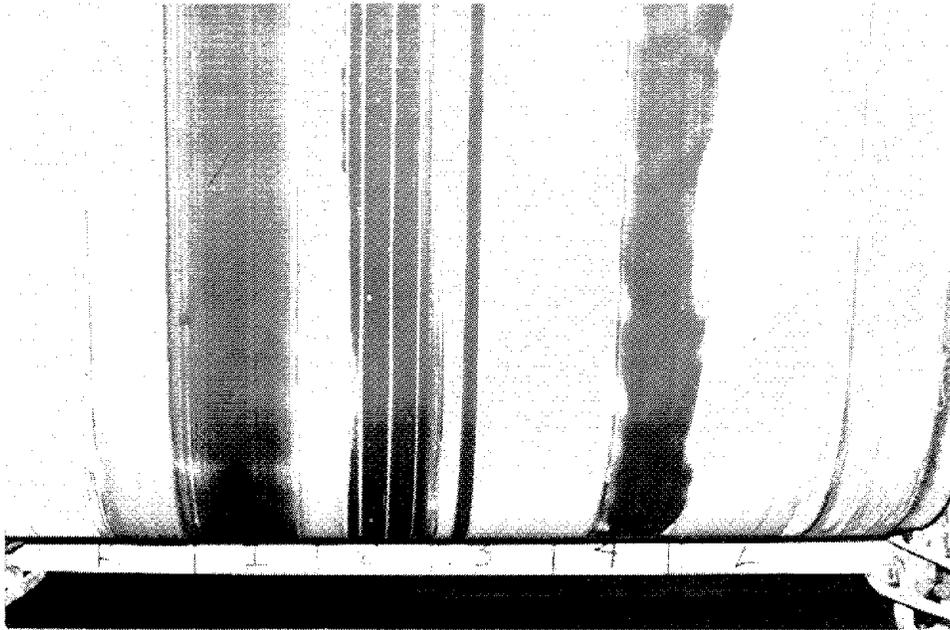


Figure 39. Comparative Cleaner Test, Series 2

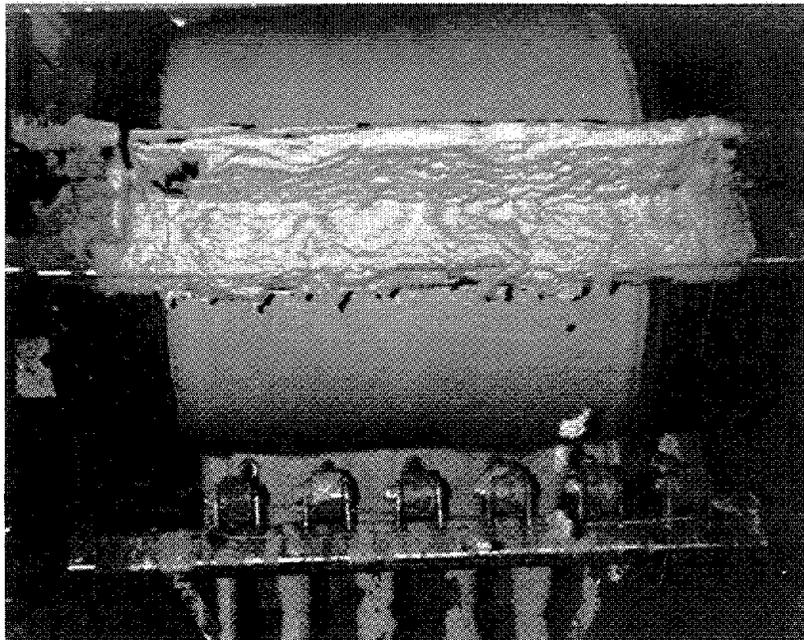


Figure 40. Commercial Belt Scraper

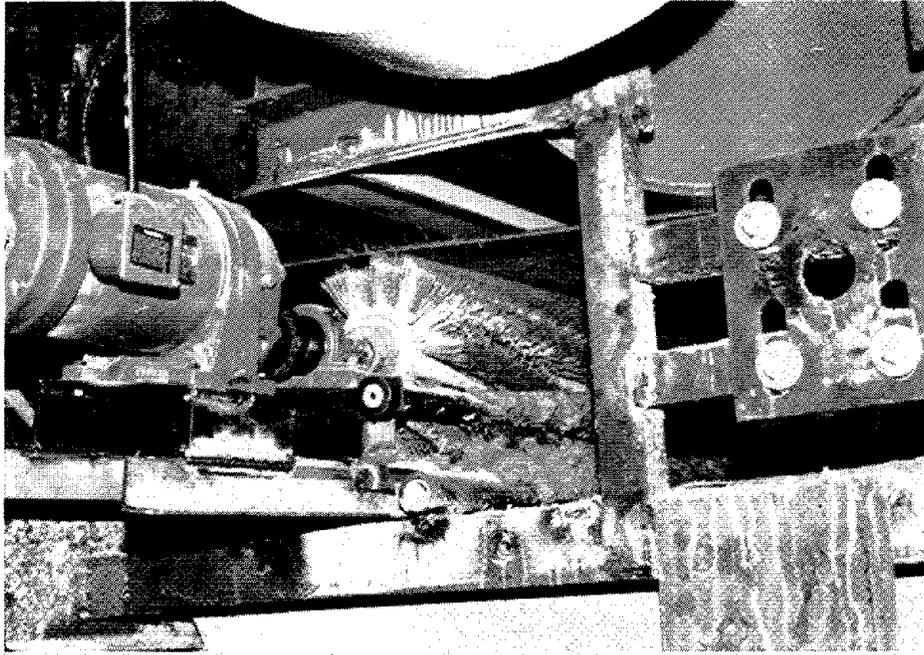


Figure 41. Motor End of Belt Brush

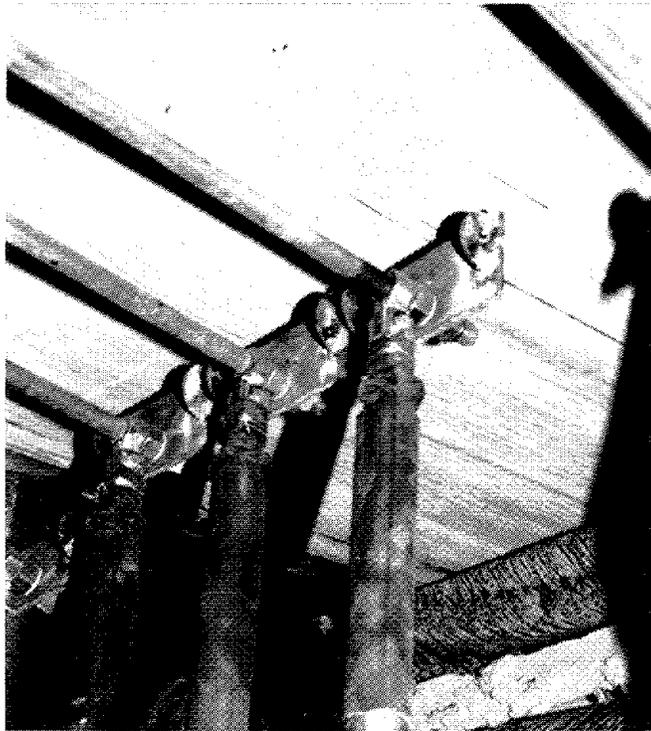


Figure 42. Modified Blade Ramps

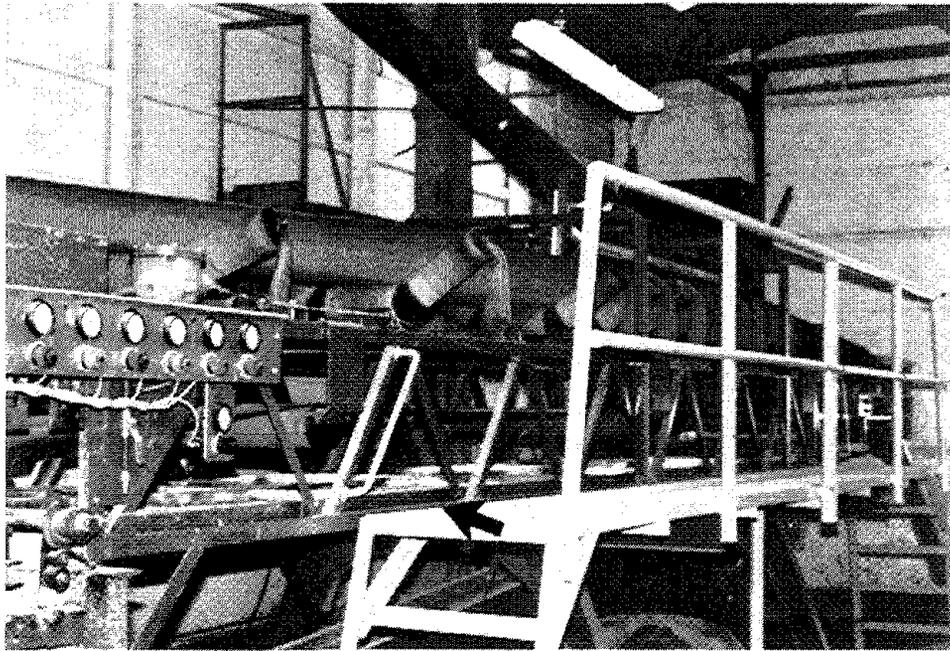


Figure 43. Spillage Pan Arrangement

Jeffrey Belt Wipers

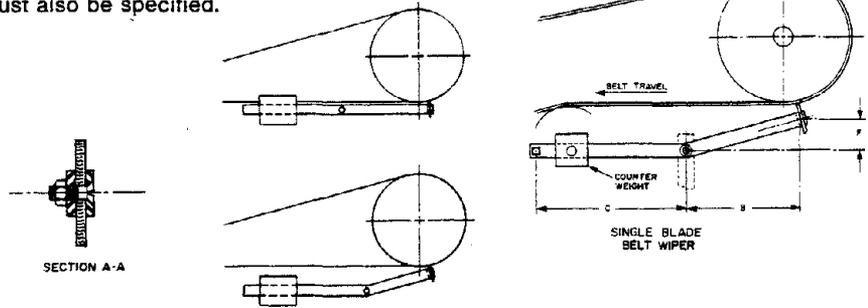
Single Blade Type

The single blade type is primarily intended for use with conveyors handling coarse or dry materials that offer little or no resistance to removal. Where moisture has been introduced as a cooling or cleaning agent, this type may be used to squeegee excess water from the belt.

Note: Dimensions B, C, D and G must be specified when ordering straight arm wipers. If bent arm wiper is required, dimension F must also be specified.

Belt Width Inches	Counterweights	
	Number Per Side	Approx. Wt. Each
14	1	11
16	1	11
18	1	11
20	1	11
24	1	11
30	1	11
36	1	11
42	1	11
48	1	11
54	1	11
60	1	11

Specifications subject to change without notice.



Duplex Blade Type

The duplex belt wiper is recommended for use where wet nonsticky materials, free from mud or dirt, are handled. The cradling of the two wiper blades in the main or counterweighted arms assures constant contact with the belt by both blades.

The two cradled wipers are, in turn, cradled from the main or counterweighted arms, assuring belt contact by all blades.

Note: Dimensions B, C, D and G must be specified when ordering straight arm wipers. If bent arm wiper is required, dimension F must also be specified.

Belt Width Inches	Counterweights	
	Number Per Side	Approx. Wt. Each
16	1	25
18	1	25
20	1	25
24	2	25
30	2	25
36	2	25
42	3	25
48	3	25
54	3	25
60	1	100
72	1	100

Specifications subject to change without notice.

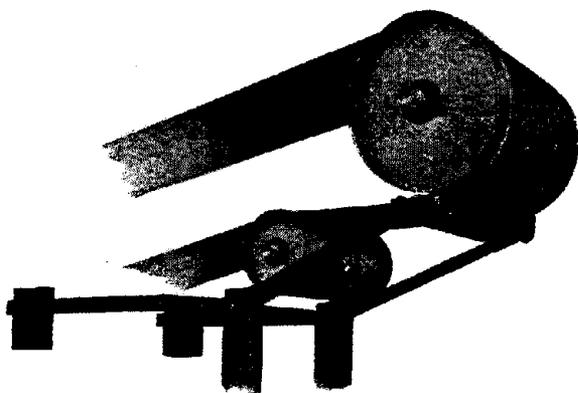
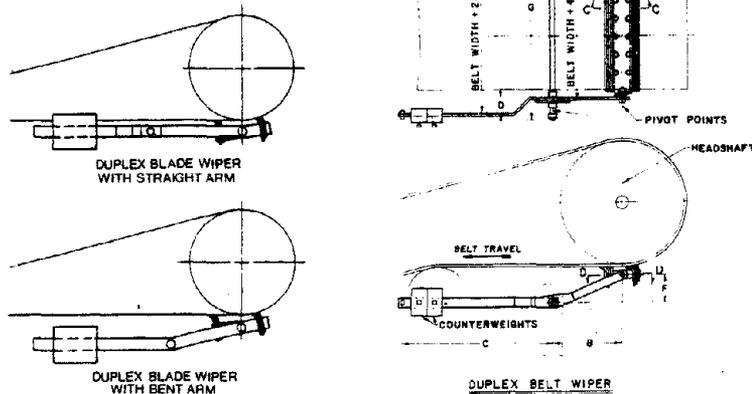
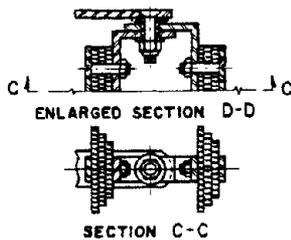


Figure 44. Wipers, Jeffrey

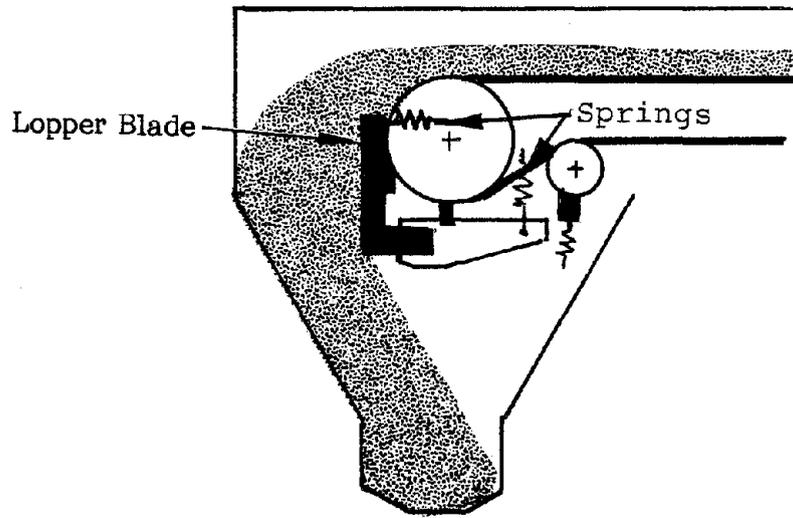
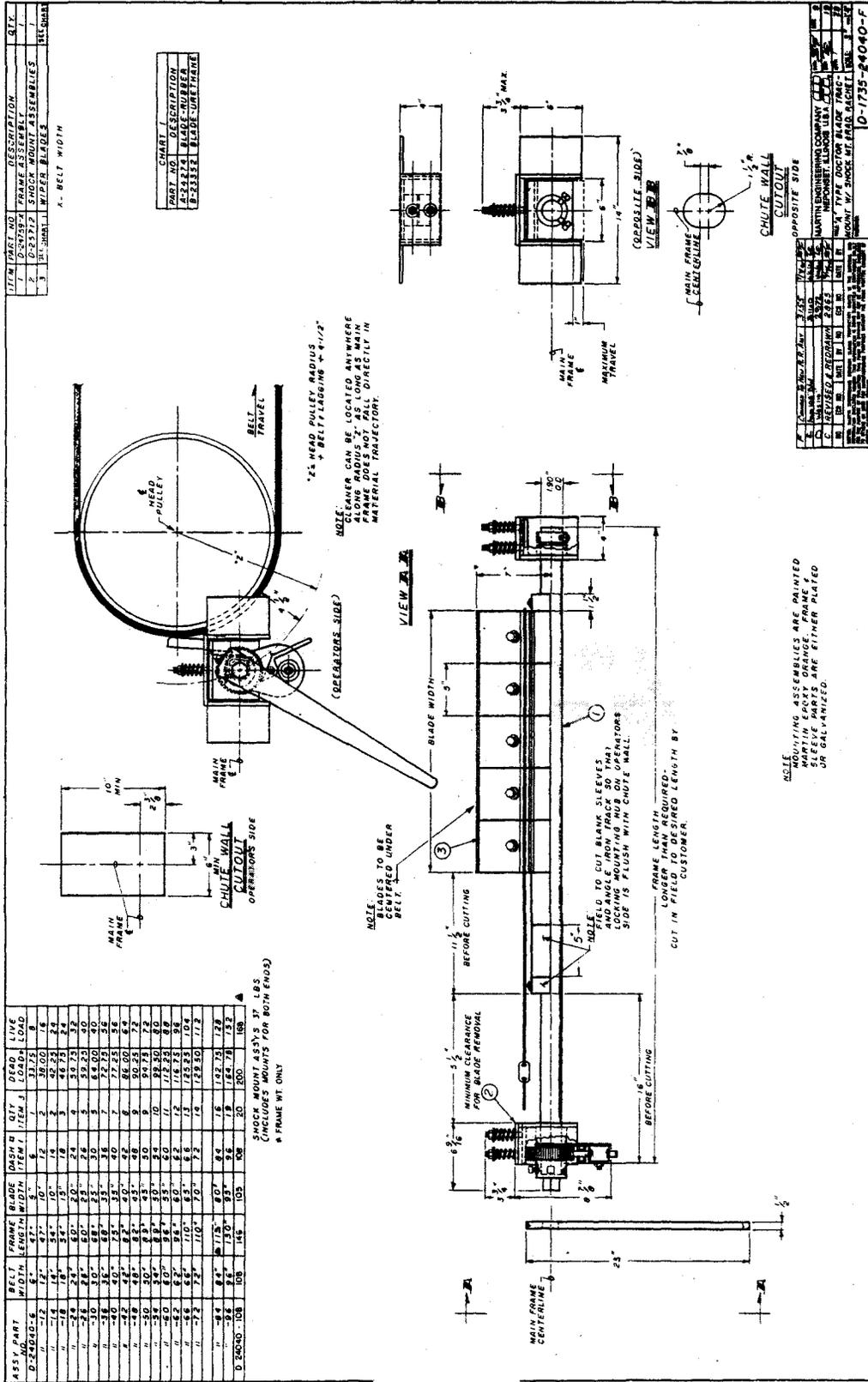


Figure 45. Lopper Blade Cleaner



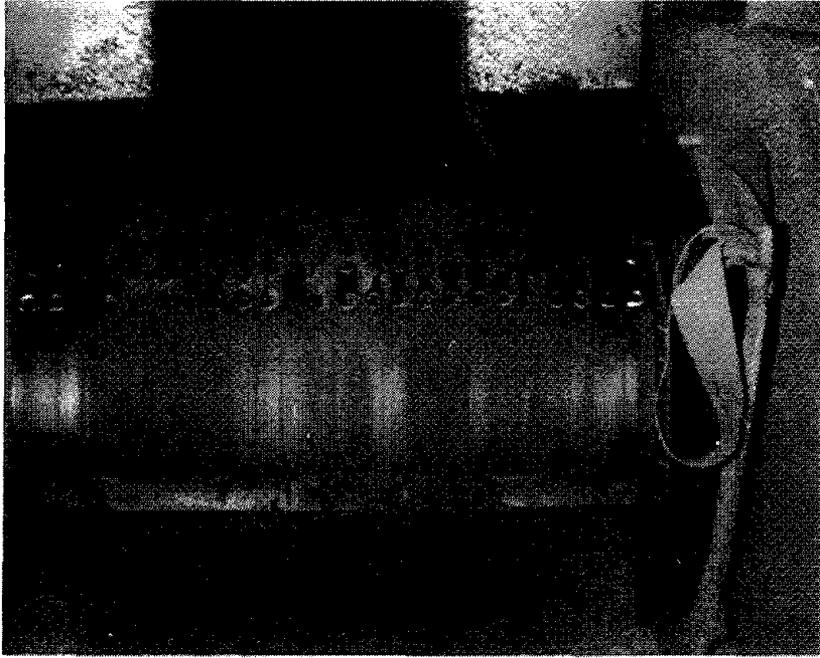


Figure 47. Shop-Made Lopper Blade

Quadruple Blade Type

The quadruple type consists of two cradles, the rear cradle being identical with the one described for the duplex wiper. There is an additional cradled wiper in front which has two blades with one strip of heavy duty rubber in each blade.

The quadruple type is a superior belt wiper recommended for use where damp sticky materials are handled, or where mud or dirt is present in the material. The two thick rubber blades on the forward cradle act as scrapers to clean off the heavy coating on the belt so that the flexible wipers complete the cleaning job.

Note: Dimensions B, C, D and G must be specified when ordering straight arm wipers. If bent arm wiper is required, dimension F must also be specified.

Belt Width Inches	Counterweights	
	Number Per Side	Approx. Wt. Each
16	1	52
18	1	52
20	1	52
24	2	52
30	2	52
36	2	52
42	3	52
48	3	52
54	3	52
60	4	52

Specifications subject to change without notice.

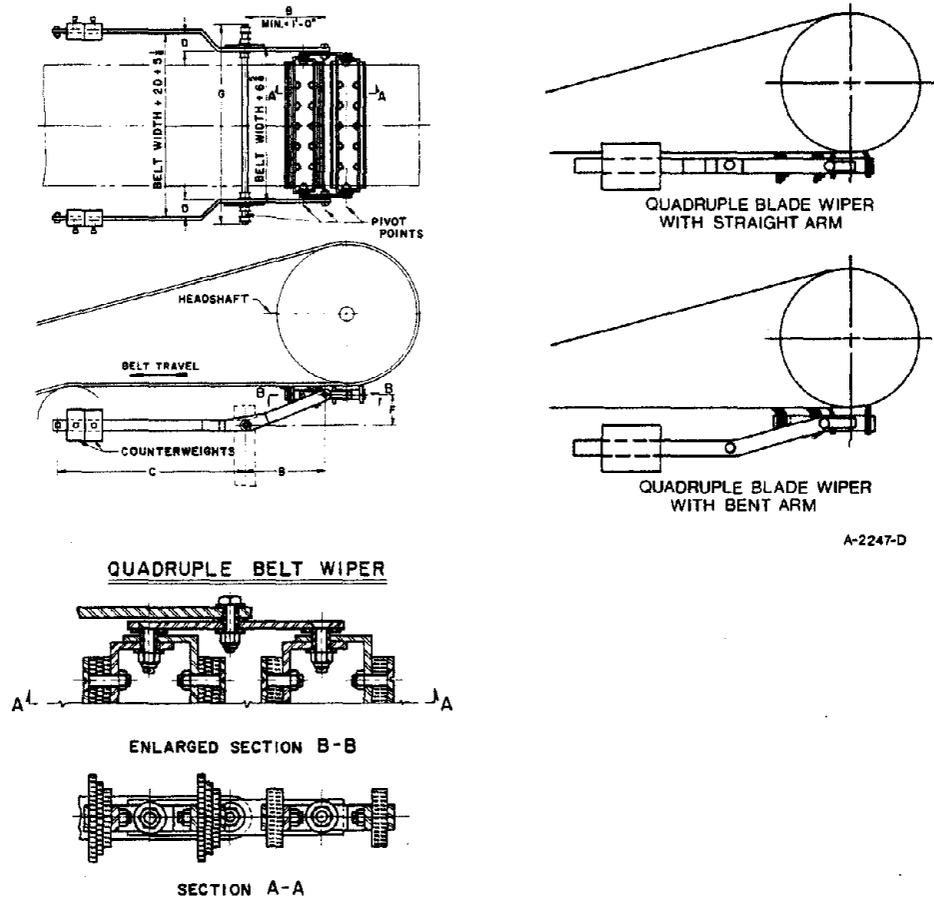


Figure 48. Multiblade Wiper, Jeffrey

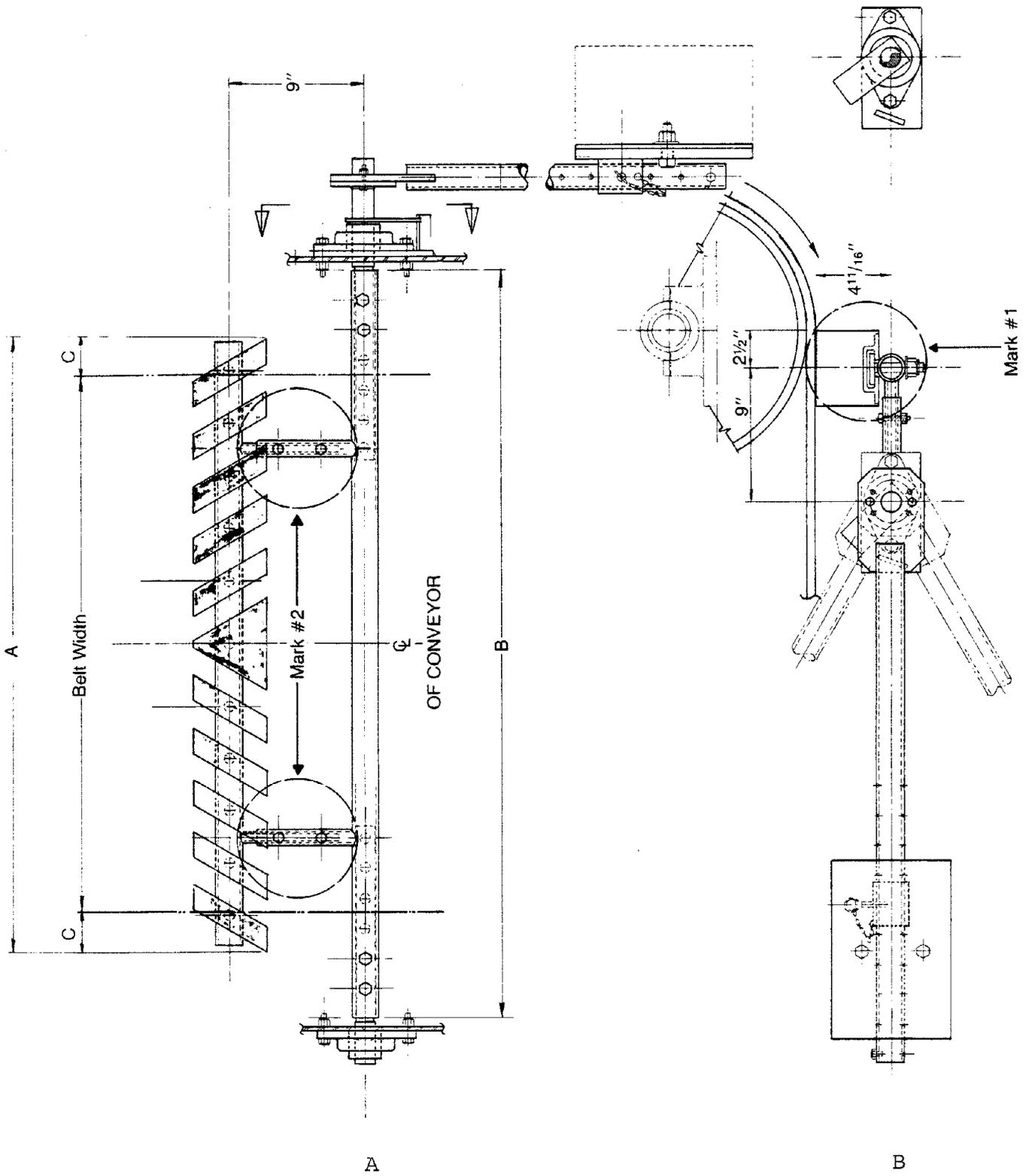
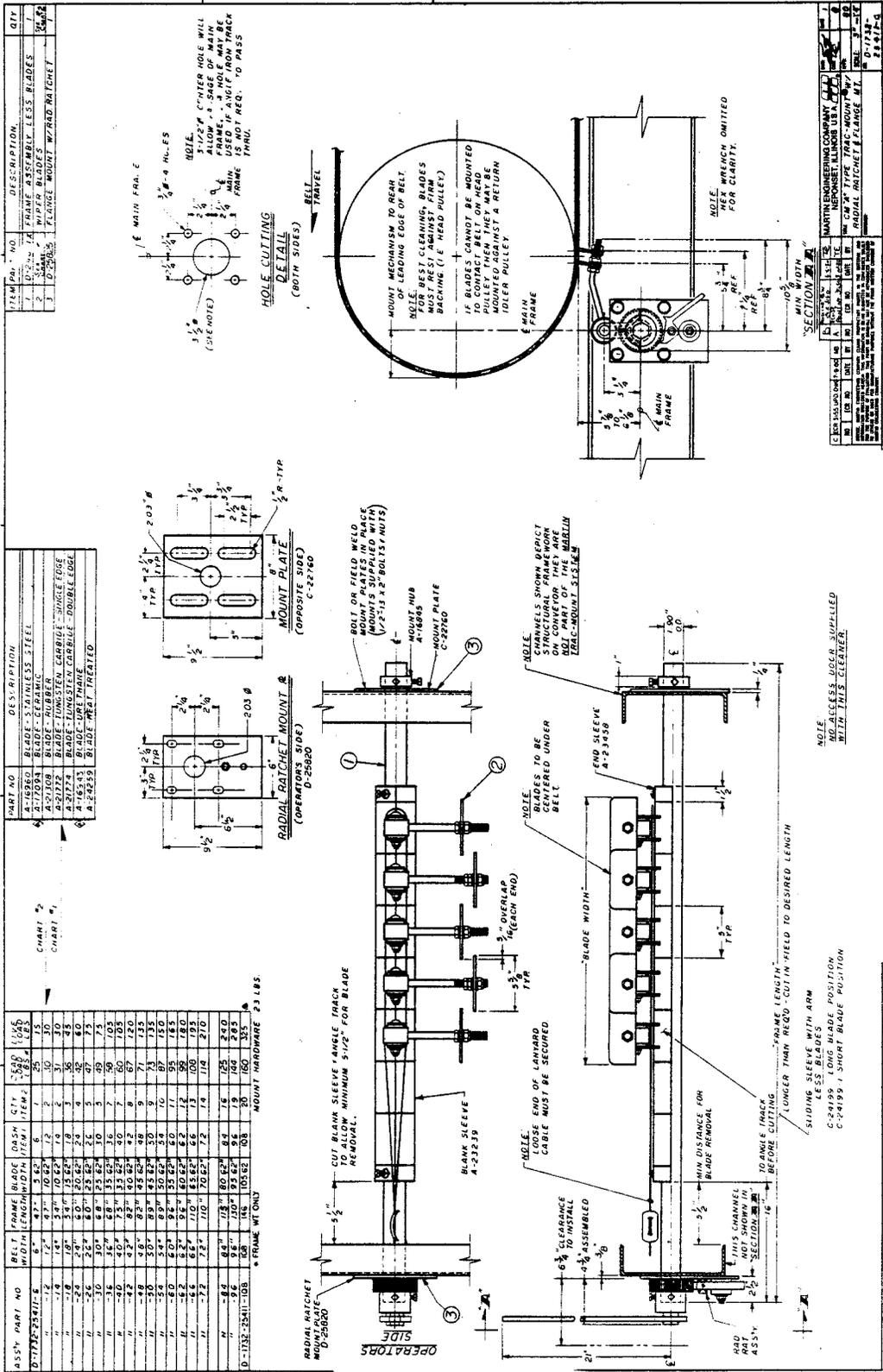
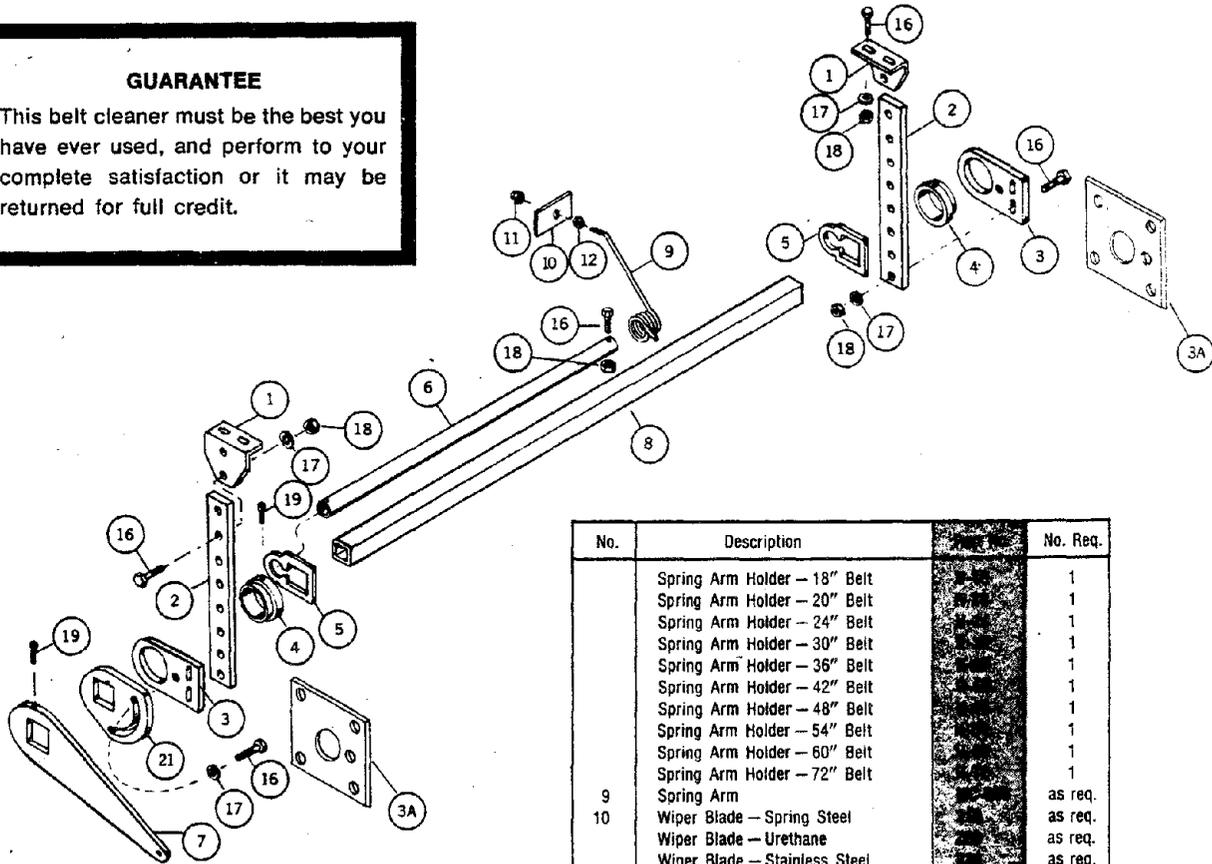


Figure 49. Wiper, Trelleborg



GUARANTEE

This belt cleaner must be the best you have ever used, and perform to your complete satisfaction or it may be returned for full credit.



**MODEL 33 EXTRA
HEAVY DUTY CONVEYOR BELT CLEANER**

No.	Description	Part No.	No. Req.
1	Hanger Clip	A-187	2
2	Hanger	A-181	2
3	Hanger Mount Plate	A-182	2
3A	Flange Mount	A-183	2
4	Collar	A-184	2
5	Arm Assembly Retainer	A-185	as req.
6	Tube - 6" Belt	T-186	1
	Tube - 12" Belt	T-187	1
	Tube - 18" Belt	T-188	1
	Tube - 20" Belt	T-189	1
	Tube - 24" Belt	T-190	1
	Tube - 30" Belt	T-191	1
	Tube - 36" Belt	T-192	1
	Tube - 42" Belt	T-193	1
	Tube - 48" Belt	T-194	1
	Tube - 54" Belt	T-195	1
	Tube - 60" Belt	T-196	1
	Tube - 72" Belt	T-197	1
7	Pressure Handle	A-198	1
8	Spring Arm Holder - 6" Belt	H-199	1
	Spring Arm Holder - 12" Belt	H-200	1

No.	Description	No. Req.
	Spring Arm Holder - 18" Belt	1
	Spring Arm Holder - 20" Belt	1
	Spring Arm Holder - 24" Belt	1
	Spring Arm Holder - 30" Belt	1
	Spring Arm Holder - 36" Belt	1
	Spring Arm Holder - 42" Belt	1
	Spring Arm Holder - 48" Belt	1
	Spring Arm Holder - 54" Belt	1
	Spring Arm Holder - 60" Belt	1
	Spring Arm Holder - 72" Belt	1
9	Spring Arm	as req.
10	Wiper Blade - Spring Steel	as req.
	Wiper Blade - Urethane	as req.
	Wiper Blade - Stainless Steel	as req.
	Wiper Blade - Stainless Steel Nickel Alloy	as req.
	Wiper Blade - Ceramic	as req.
	Wiper Blade - Tungsten Carbide	as req.
11	Flange Lock Nut	as req.
12	Flange Nut	as req.
16	Hex Hd. Cap Screw	as req.
17	Lock Washer	as req.
18	Hex Nut	12
19	Square Hd. Set Screw	3
21	Locking Plate	1
	Complete Assembly - 6" Belt	MS-18
	Complete Assembly - 12" Belt	MS-19
	Complete Assembly - 18" Belt	MS-20
	Complete Assembly - 20" Belt	MS-21
	Complete Assembly - 24" Belt	MS-22
	Complete Assembly - 30" Belt	MS-23
	Complete Assembly - 36" Belt	MS-24
	Complete Assembly - 42" Belt	MS-25
	Complete Assembly - 48" Belt	MS-26
	Complete Assembly - 54" Belt	MS-27
	Complete Assembly - 60" Belt	MS-28
	Complete Assembly - 72" Belt	MS-29
	- Specify blade type desired when ordering complete assembly.	
	Note: All unplated parts are painted with a high quality enamel paint.	



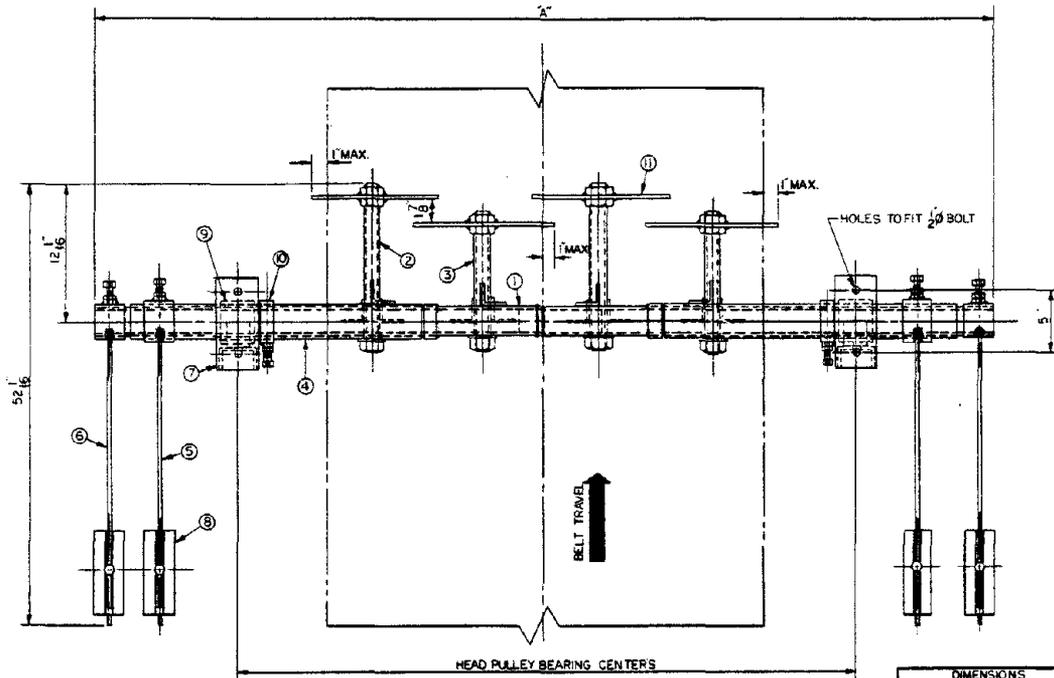
MATERIAL CONTROL, INC.

719 Morton Ave. • Aurora, Ill. 60506

Phone: (312) 892-4274 or 892-9767

Figure 51. Segmented Scraper, Material Control

TYPE 50/SINGLE STAGE BELT CLEANER ASSEMBLY



DIMENSIONS			
B W	A	B W	A
18	51 1/2	48	85 1/2
20	53	54	91
24	57	60	97
30	63	66	103
36	73	72	109
42	79		

TYPE 50/2 STAGE BELT ASSEMBLY CLEANER

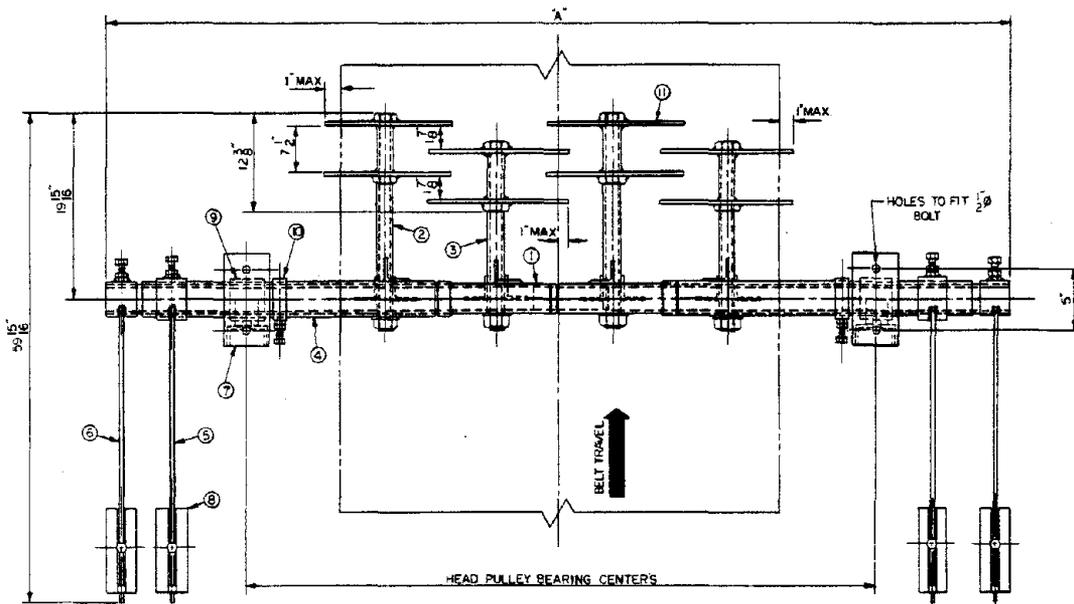


Figure 52. Segmented Scraper, Dick

Model 99 BRUSH CLEANER • COMPLETE • READY TO INSTALL

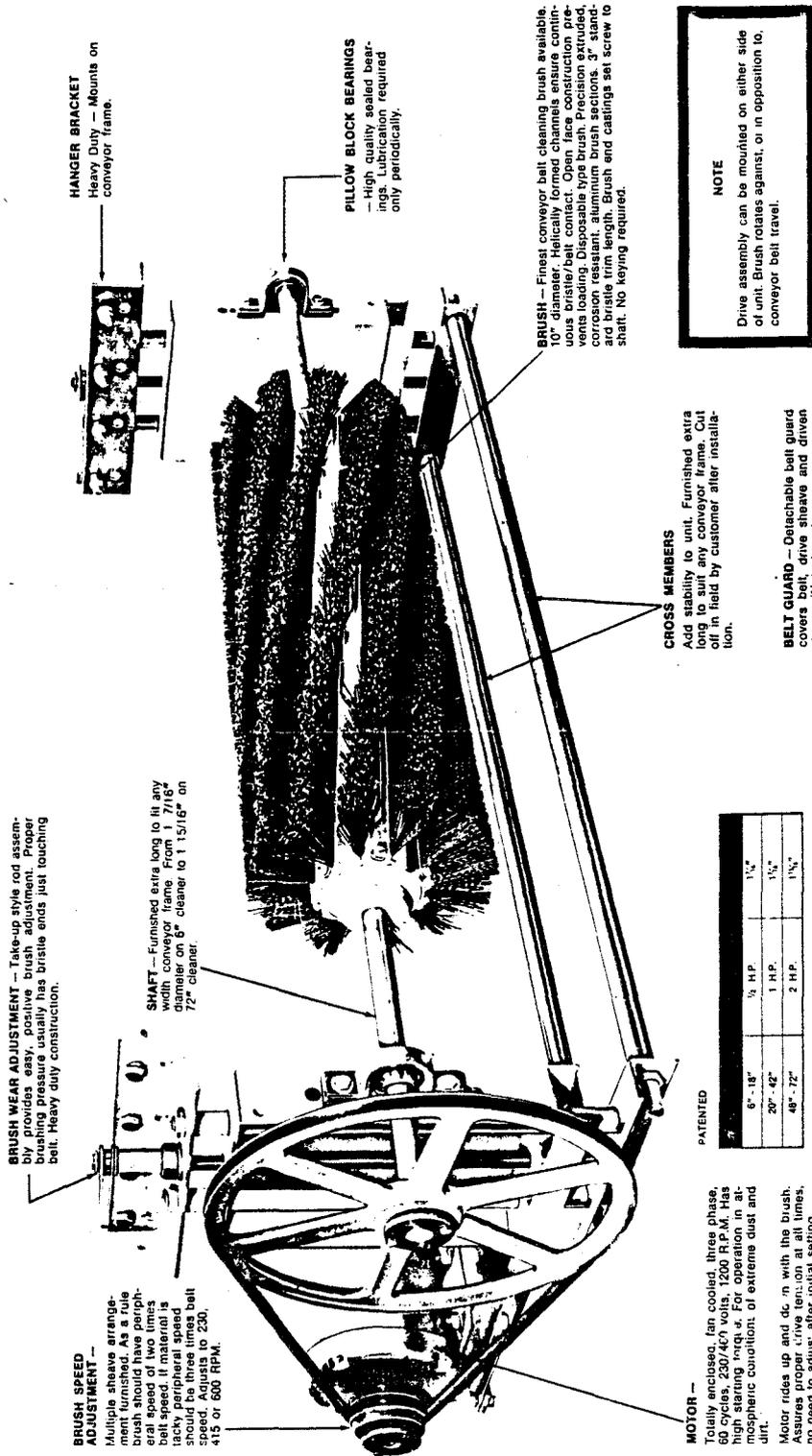
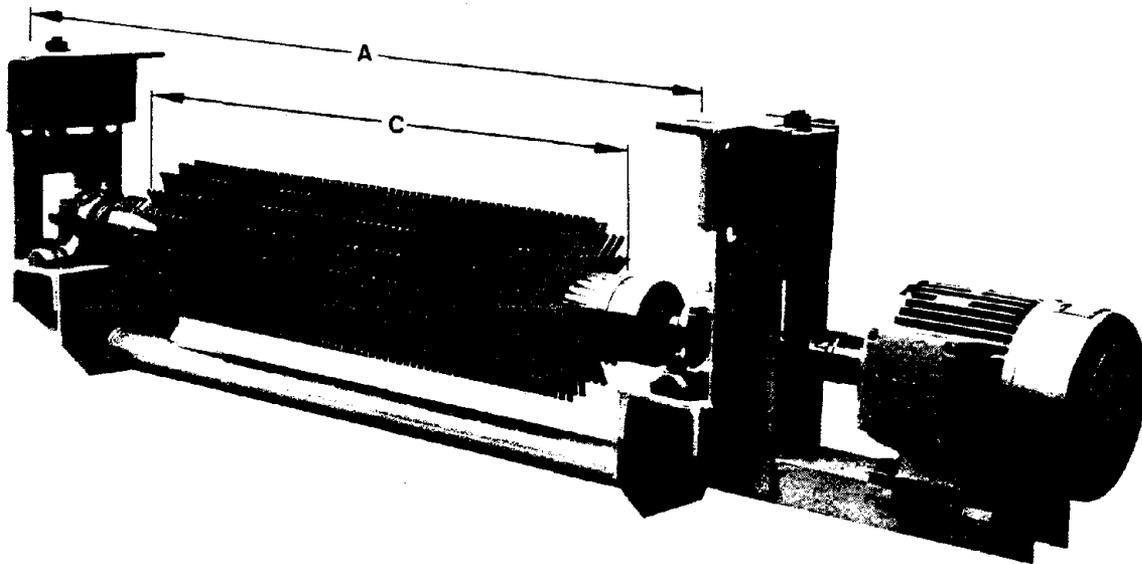


Figure 53. Rotary Brush, Material Control



The belt cleaning brush is available in standard quality or in Quality V.

Belt cleaning brush assembly
(Metal tube with shafts, coupling, twin pivot ball bearing, bearing housing, suspension and optional electric motor 220/380 V and 500 V)

Technical data:

For belt width	Suspension (A)	Length of metal tube (C)	Motor with clutch drive
400 mm	625 mm	535 mm	0,55 kw approx. 900 r.p.m.
500 mm	910 mm	635 mm	0,55 kw approx. 900 r.p.m.
650 mm	1040 mm	785 mm	0,75 kw approx. 900 r.p.m.
800 mm	1300 mm	935 mm	0,75 kw approx. 900 r.p.m.
1000 mm	1440 mm	1135 mm	0,75 kw approx. 900 r.p.m.
1200 mm	1880 mm	1335 mm	1,1 kw approx. 900 r.p.m.
1400 mm	2080 mm	1535 mm	1,1 kw approx. 900 r.p.m.
1600 mm	2280 mm	1735 mm	1,1 kw approx. 900 r.p.m.
1800 mm	2480 mm	1935 mm	1,5 kw approx. 900 r.p.m.
2000 mm	2680 mm	2135 mm	1,5 kw approx. 900 r.p.m.

On request available up to a belt width of 3000 mm!

Figure 54. Rotary Brush, Tip Top

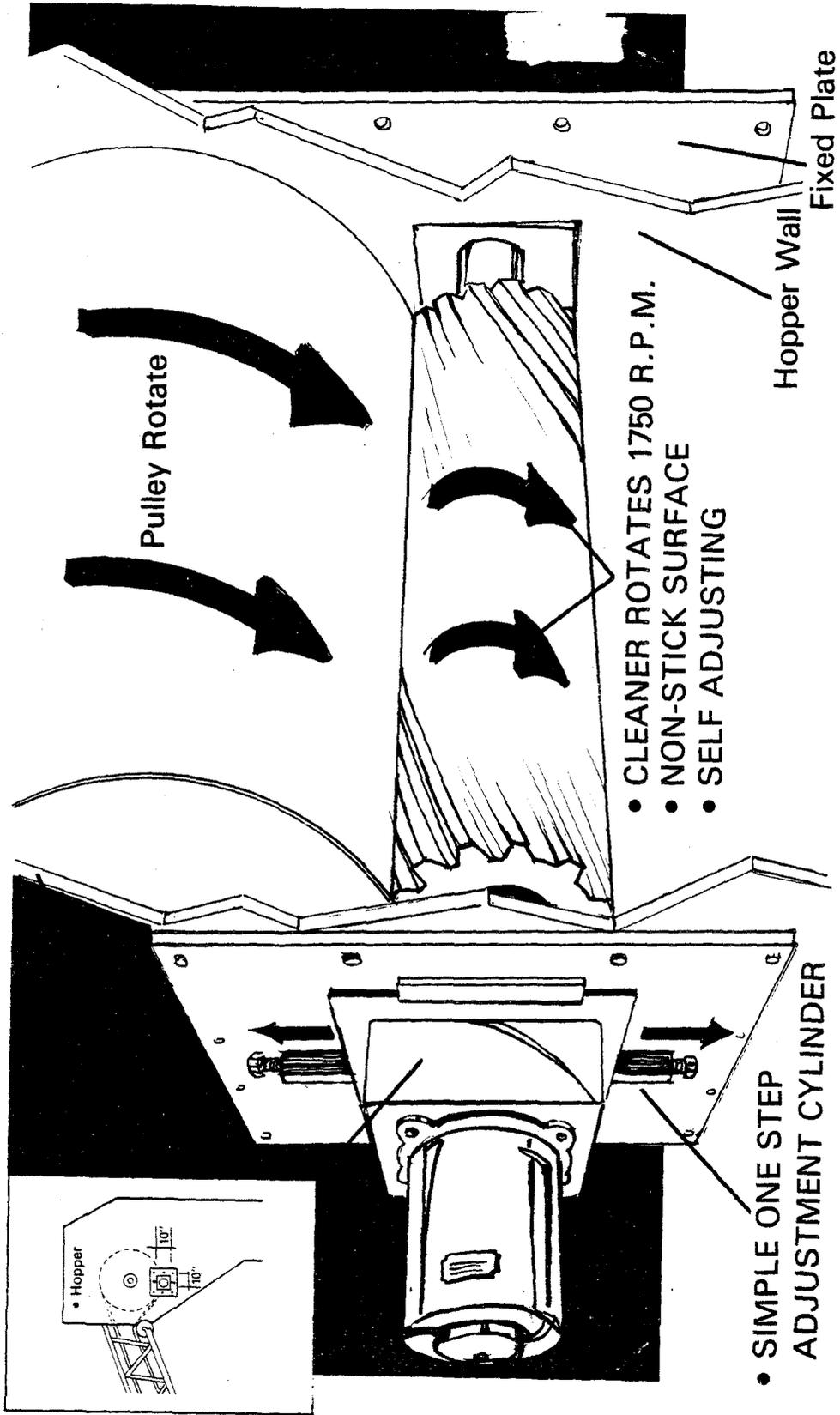


Figure 55. Rotary Wiper, Cottrell

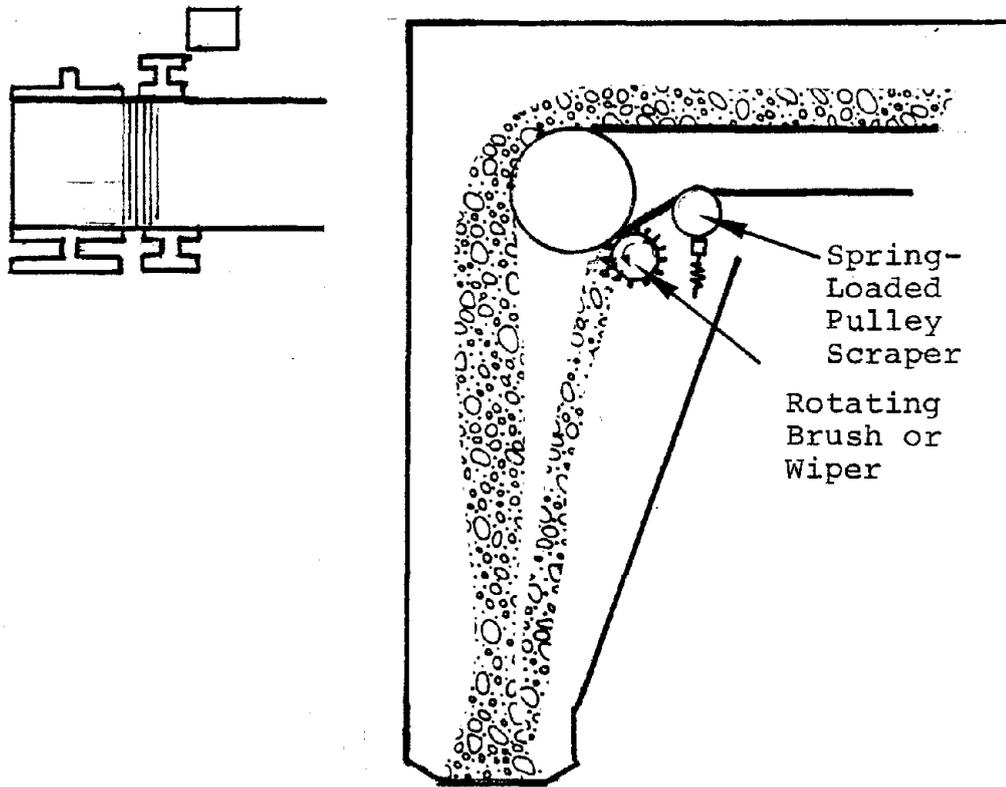
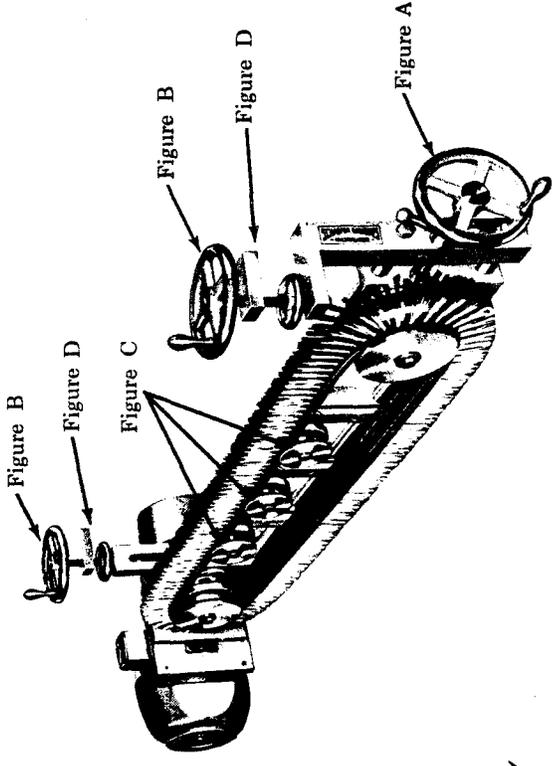


Figure 56. Rotary-Powered Belt Cleaner

THE SCHAEFER SAVED BELT CLEANER

**EMPLOYS A
BRAND NEW
CONCEPT IN
CONVEYOR
CLEANING!**



The brushes of a V-belt construction are filled with tufts of "Tynex" nylon to make a flexible continuous cleaning unit.

Brushes are mounted on double sheaves, powered by a 3 h. p. motor and V-belt drive.

The entire unit can be supported from the Conveyor I Beam frame and the brushes rotate across the belt or 90° to the direction of the conveyor travel, thereby providing double action cleaning as the belt passes over the brush.

Proper tension of the brushes is maintained by a belt tightening assembly, as shown in Figure A.

Contact between the brush and conveyor belt is maintained by the height adjustment elevating screws as shown in Figure B.

Proper brush to conveyor contact is further insured by 3 idler pulleys, Figure C, fully adjustable to allow brush to conform to any conveyor contour or loading pattern.

Brush replacement is a simple matter of releasing the belt tightening assembly, then lowering the unit on the elevating screws and replacing the brushes. Tension and height adjustments are made and the unit is again ready for service, all in a matter of minutes. *No tools are required.*



Figure 57. Cross-Brush Cleaner, Schaefer

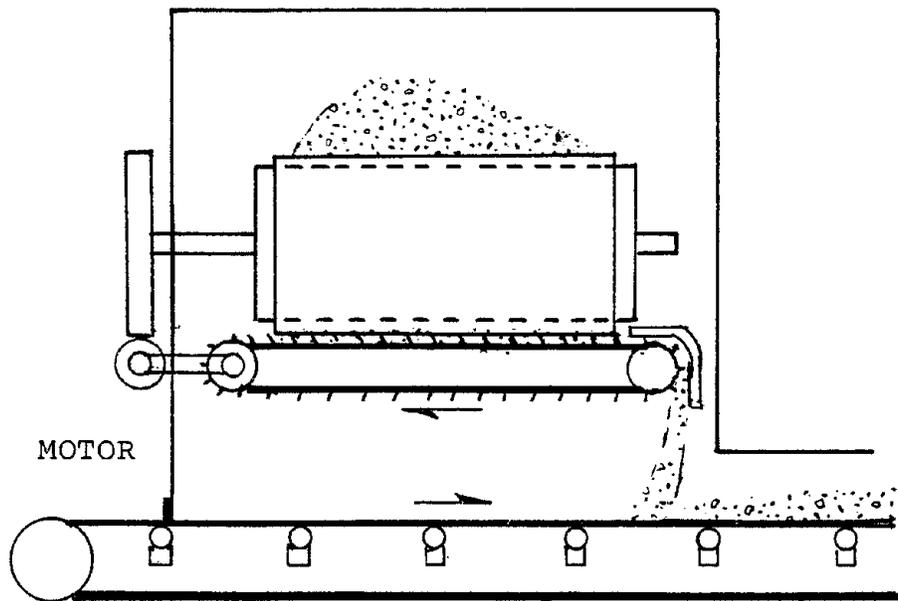
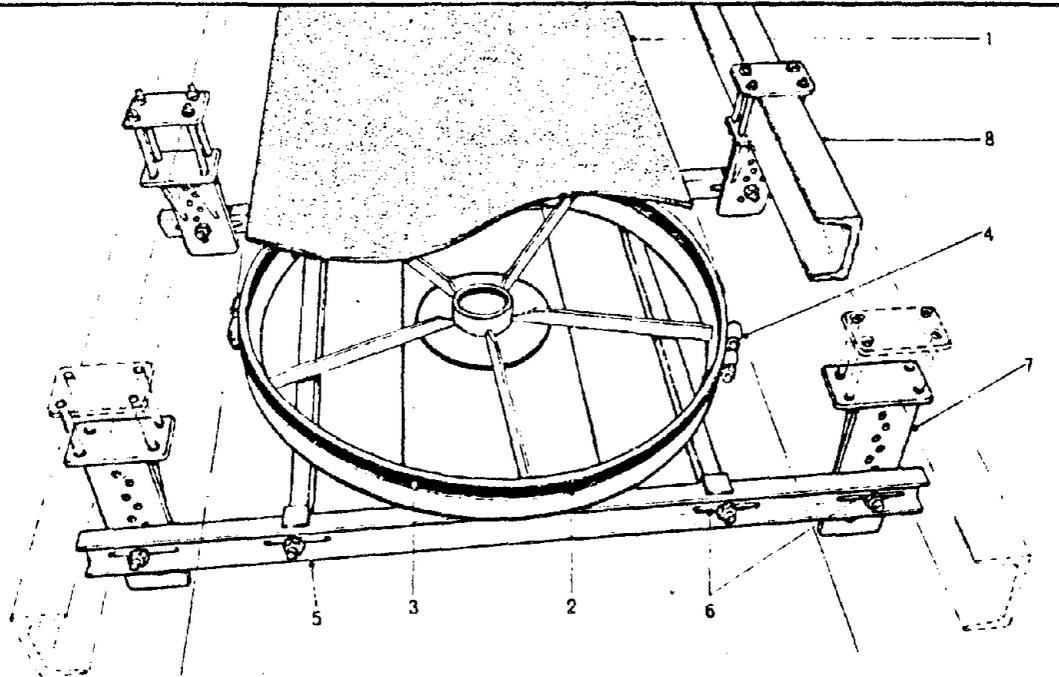


Figure 58. Cross-Belt Powered-Brush Cleaner

Installation:



Simple construction

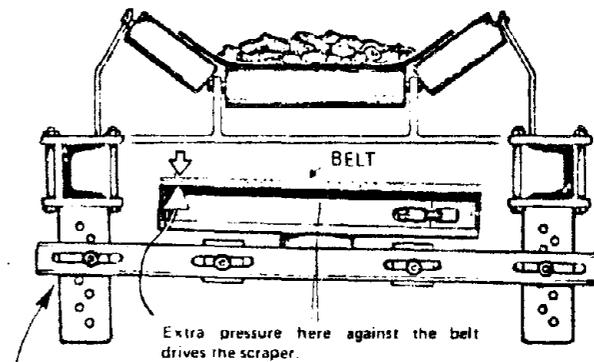
The PTI Rotary Belt Cleaner consists of a frame, two crossmembers, four brackets, and a wheel which turns on a sealed-for-life bearing assembly. Around the wheel is clamped a scraper band. The band's scraping edge is exposed above the circumference of the wheel. When the scraping edge has worn down, the clamp is loosened, the edge moved up, and the clamp tightened again.

- | | |
|------------------|----------------------------|
| 1. Conveyor belt | 5. Adjustable crossmember |
| 2. Scraper wheel | 6. Slotted adjusting holes |
| 3. Scraper band* | 7. Multi-holed bracket |
| 4. Clamping band | 8. Conveyor structure |

*Scraper band can be replaced by old belting, rubber, urethane, many other inexpensive materials.

Easy to install and adjust

1. Bolt the multi-holed bracket to the conveyor
2. Adjust the wheel's position so that the scraping edge presses against the belt
3. Tilt the wheel across the belt just enough to make the belt drive the wheel. A one-hole difference in the height of the crossmembers side to side should be enough. If a finer adjustment is needed, spacers can be clamped between the conveyor structure and the bracket.
4. When the scraping edge becomes worn down to within $\frac{3}{4}$ " of the wheel, loosen the clamp and move the scraper band upward to restore clearance. Always make sure the edges of the wheel and clamping ring are lined up evenly.
5. For maintenance or adjustment, remove bracket bolts on one side of the conveyor and swing the wheel down and out of the way of the conveyor belt



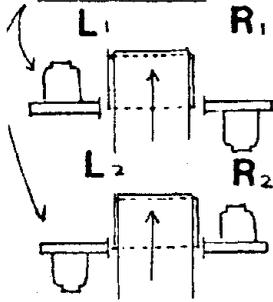
Showing sideways tilt of scraper wheel by one hole adjustment of crossmember to the support bracket

Figure 59. Rotating Wiper, Plastic Techniques

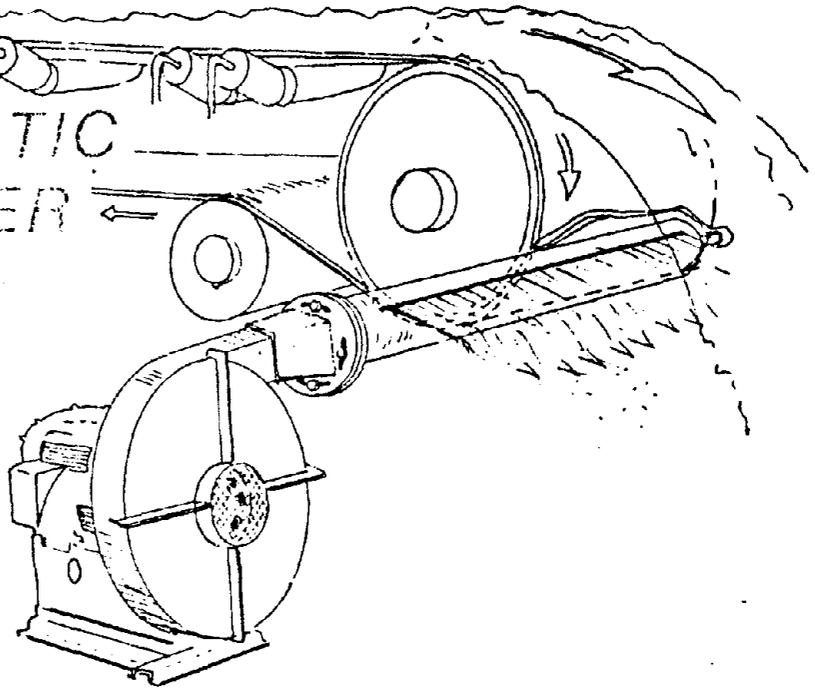
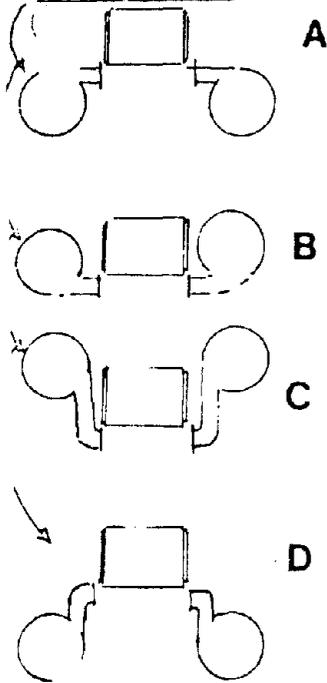
INCO PNEUMATIC BELT CLEANER

VARIOUS COMBINATIONS OF POSITIONS OF FAN AND BELT CLEANER

LOOKING DOWN ON HEAD PULLEY



FACING HEAD PULLEY



EXAMPLE: R₂ A

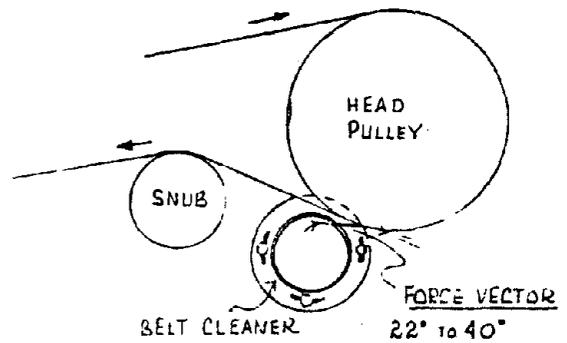


Figure 60. Pneumatic Cleaner, Indiana Steel

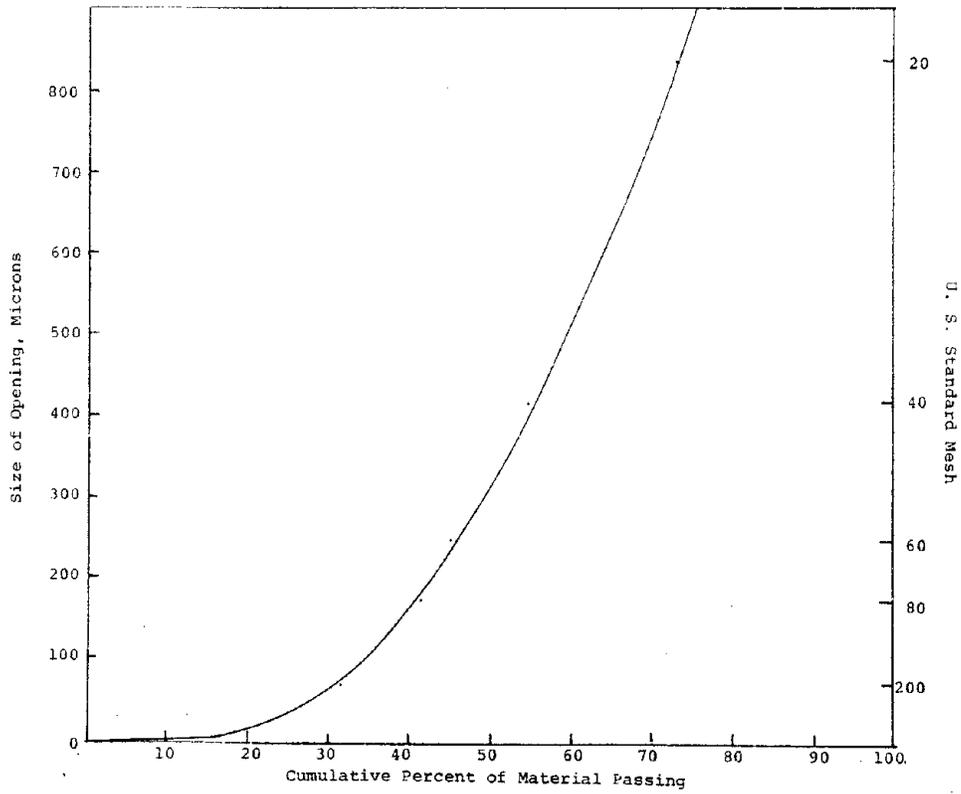


Figure 61. Screen Analysis; Material - Coal

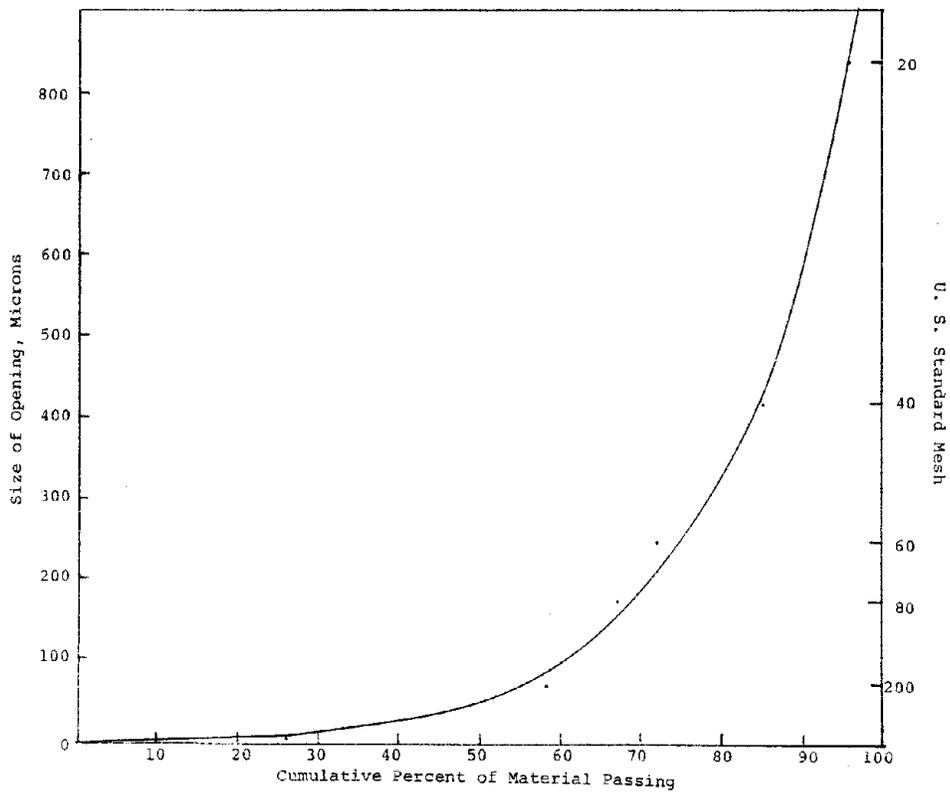


Figure 62. Screen Analysis; Material - Coal

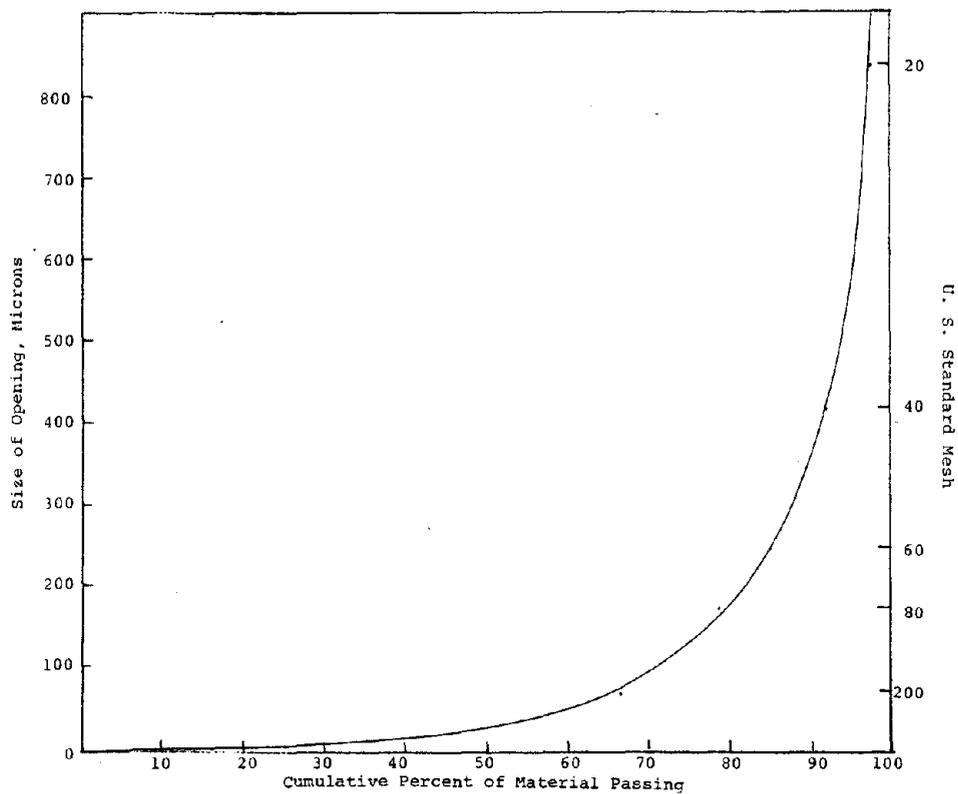


Figure 63. Screen Analysis; Material - Coal

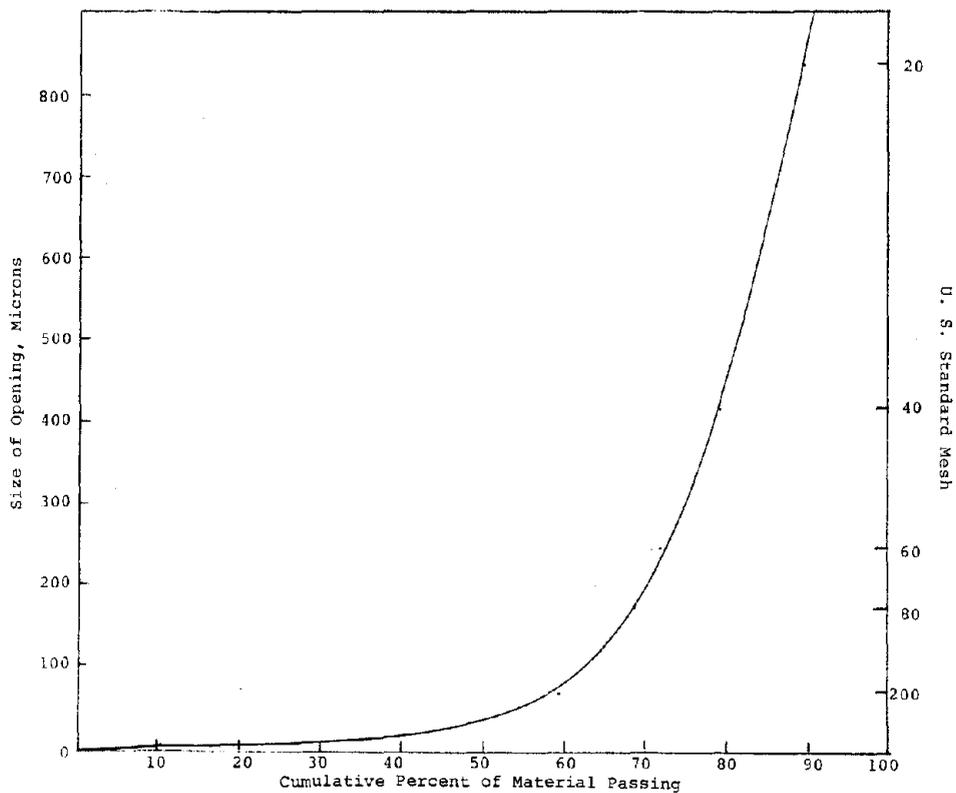


Figure 64. Screen Analysis; Material - Limestone

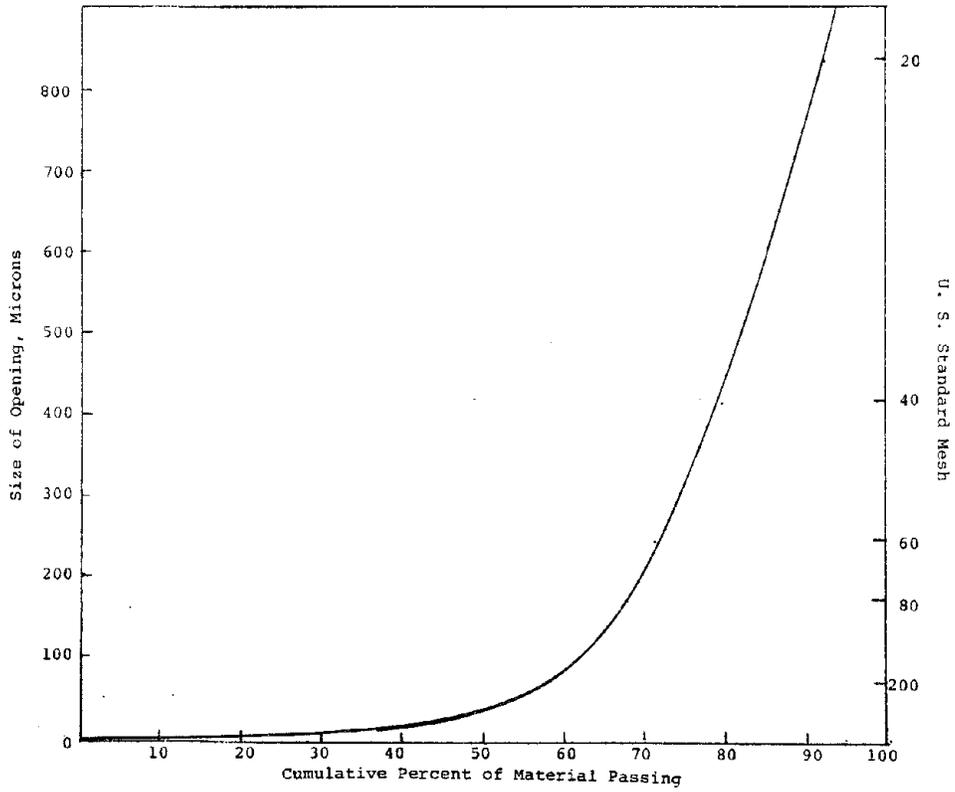


Figure 65. Screen Analysis; Material - Limestone

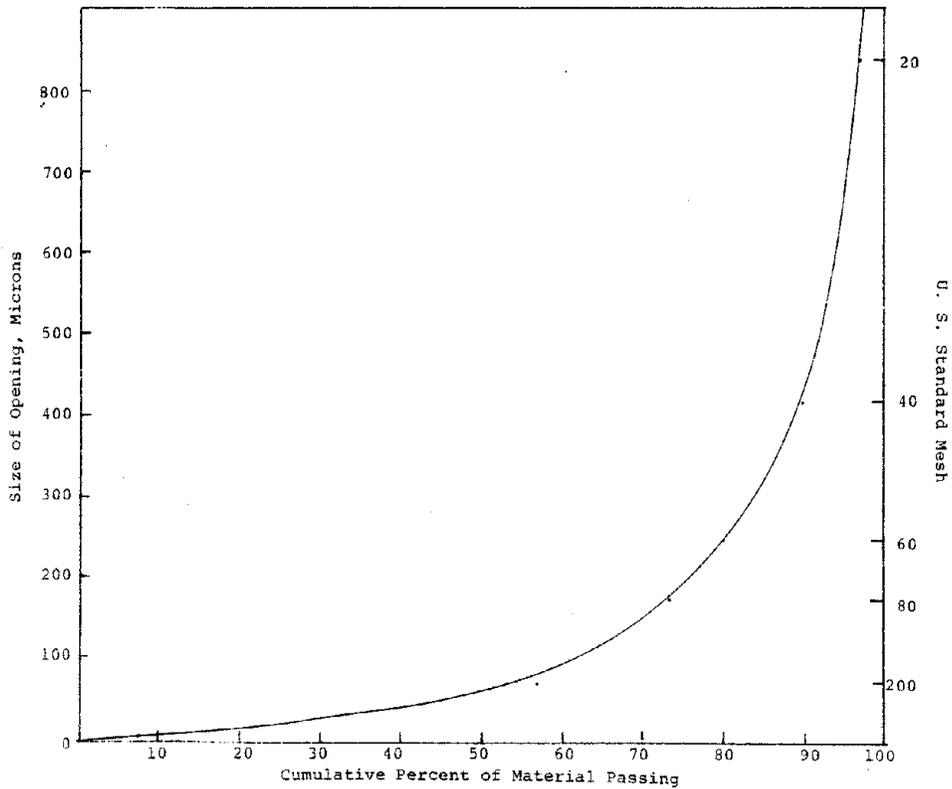


Figure 66. Screen Analysis; Material - Limestone

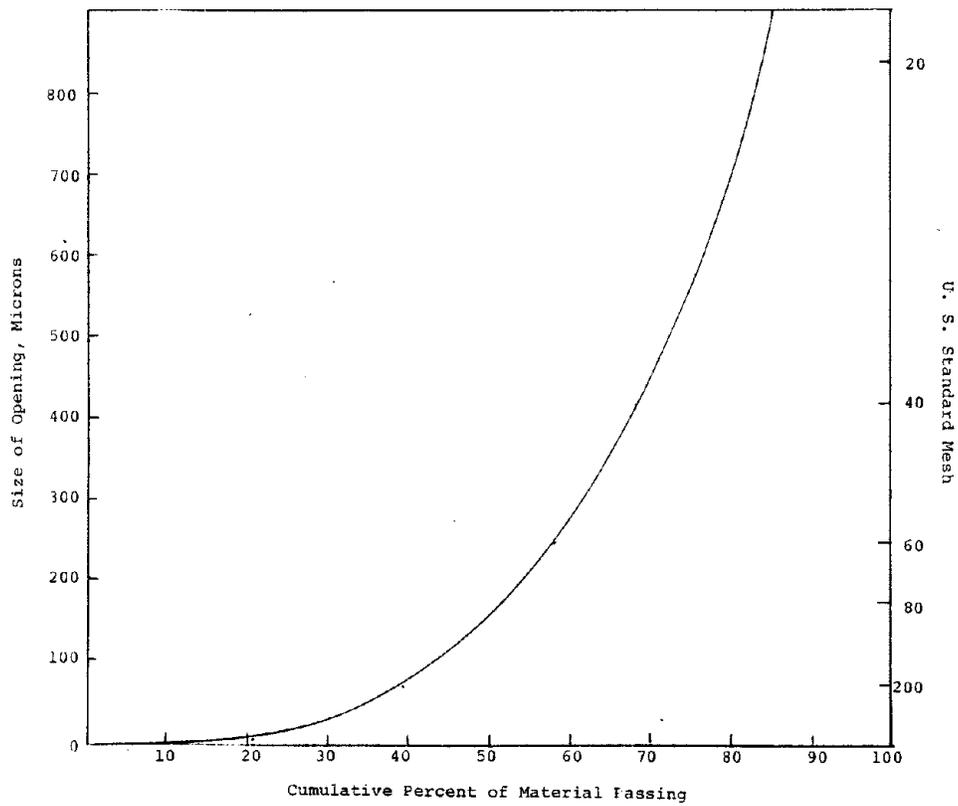


Figure 67. Screen Analysis; Material - Coal

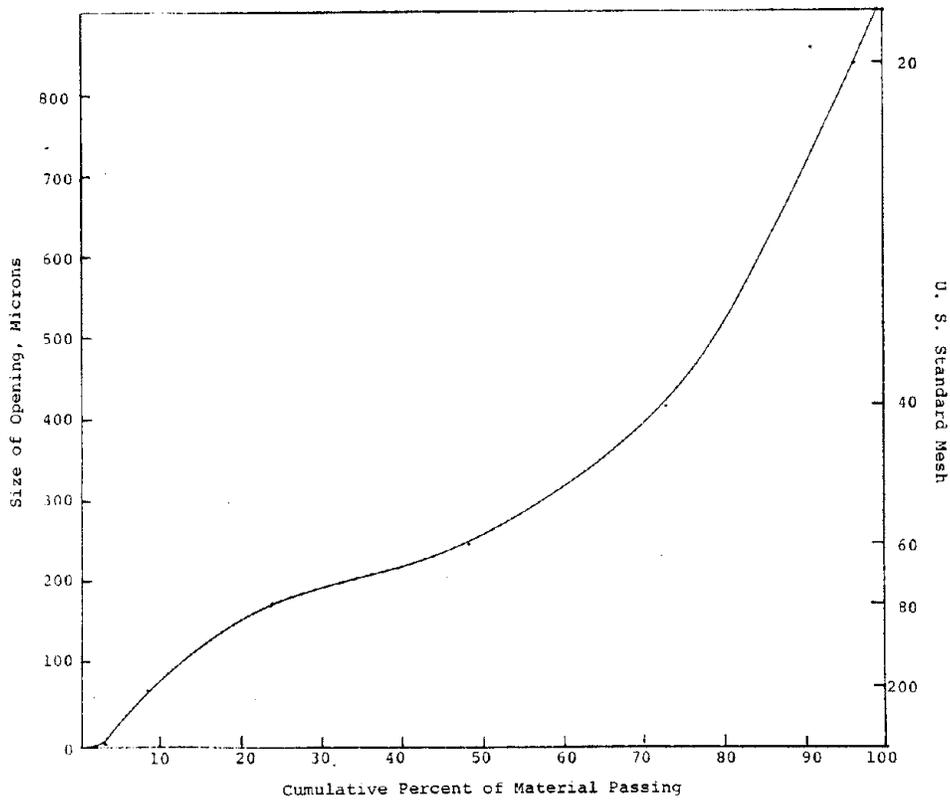


Figure 68. Screen Analysis; Material - Ore

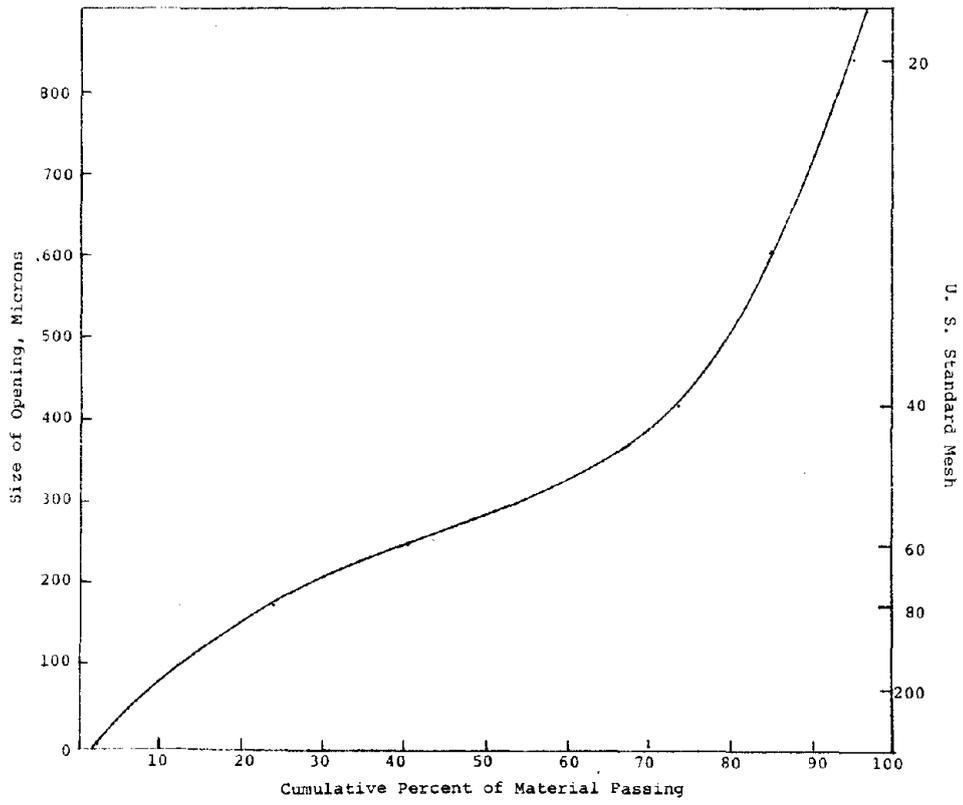


Figure 69. Screen Analysis; Material - Ore

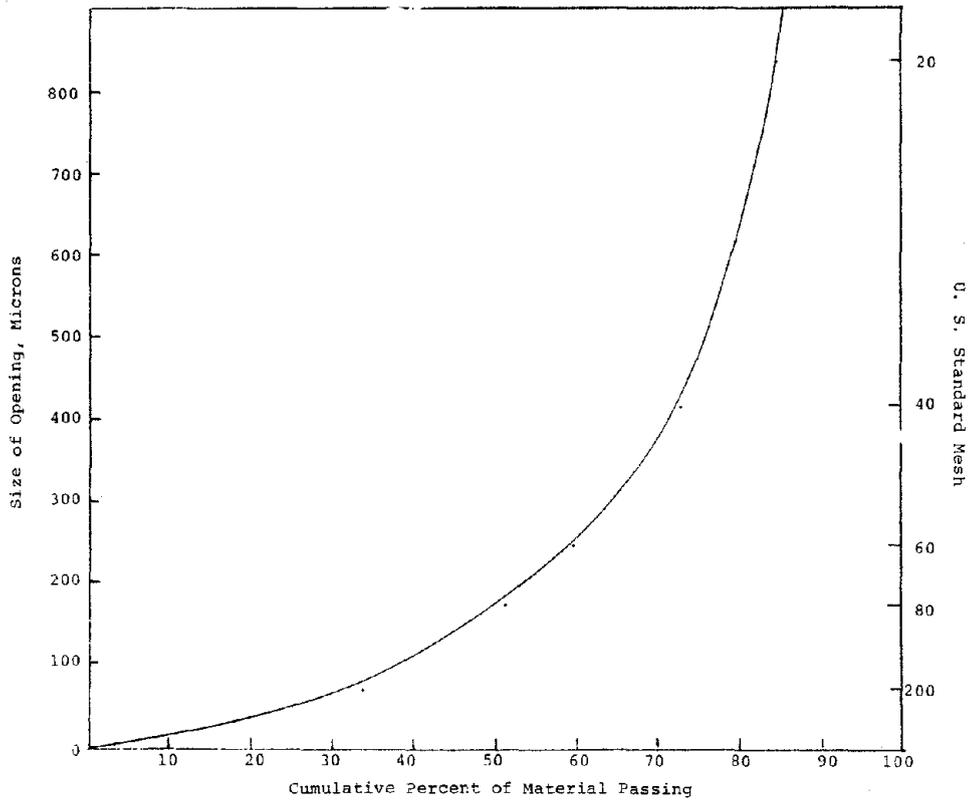


Figure 70. Screen Analysis; Material - Ore Fines

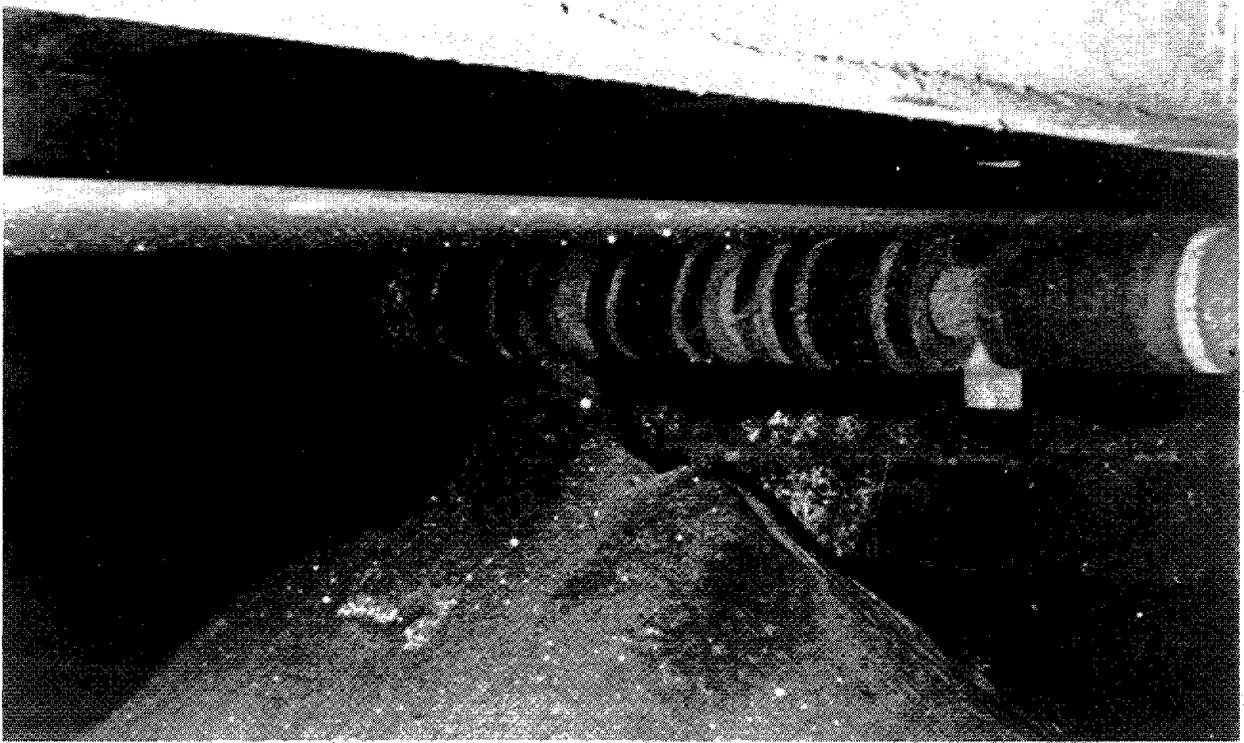


Figure 71. Disc Return Idler and Fall-Off Material

APPENDIX
TEST PROCEDURES

Test Procedure 1

- 1 Install test actions (figure A1).
- 2 Check equipment train belt conveyor.
- 3 Add materials and water.
- 4 Stabilize system.
- 5 Mount and adjust spreader (figure A2).
- 6 Engage lopper blade action 1 (figure A3).
- 7 Engage action 2 and set pressure (figures A4 and A5).
- 8 Engage action 3 and set pressure (figure A6).
- 9 Run wear-in period.
- 10 Adjust moisture content.
- 11 Stop system and install collector pans (figure A7).
- 12 Start system and clock.
- 13 Check and adjust moisture content every 30 minutes.
- 14 Stop system and clock.
- 15 Collect test side sample of material carried over (figure A8).
- 16 Collect standard side sample of material carried over (figure A8).
- 17 Collect load sample (figure A9).
- 18 Collect lopper blade sample (figure A10).
- 19 Collect test side sample of material carried back (figure A11).
- 20 Collect standard side sample of material carried back (figure A11).
- 21 Collect test side spillage sample at three stations (figure A12).
- 22 Collect standard side spillage sample at three stations (figure A12).
- 23 Weigh all samples.
- 24 Lift spreader.
- 25 Clear system of material.
- 26 Shut down system and clean up.

Test Procedure 2

- 1 Install blades--four different materials (figure A13).
- 2 Check equipment, train belt.
- 3 Add material and water.
- 4 Stabilize system.
- 5 Mount and adjust spreader (figure A14).
- 6 Engage lopper blade (figure A15).
- 7 Engage blades and set pressure (figure A16).
- 8 Run (wear-in period).
- 9 Adjust moisture content.
- 10 Adjust test pressure on blades (figure A16).
- 11 Run (wear-in period).
- 12 Check moisture.
- 13 Sample; that is, repeatedly scrape 6.25 square feet (figure A17).
Reiterate 9 through 13 at 5 lb/in.² increments to 40 lb/in.².
- 14 Weigh sample.
- 15 Divide by area scraped for carry-back load g/ft².

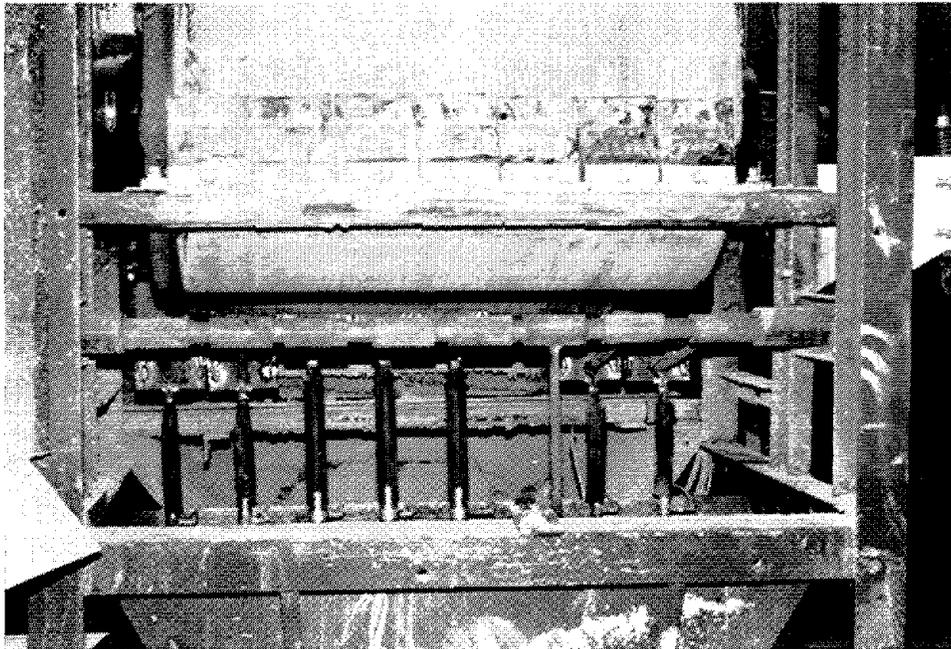


Figure A1. Installed Test Action

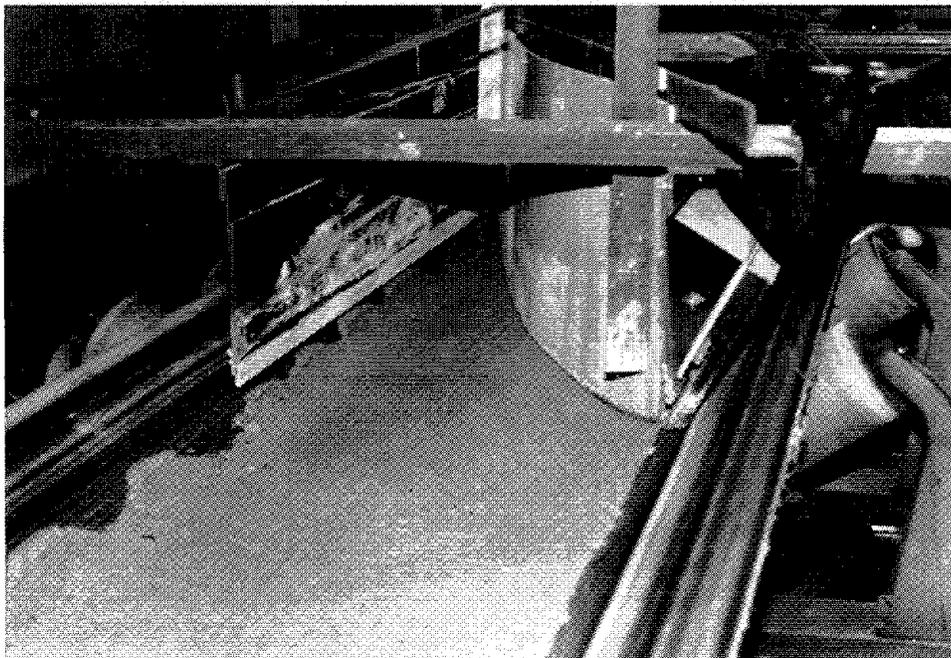


Figure A2. Mounted and Adjusted Spreader

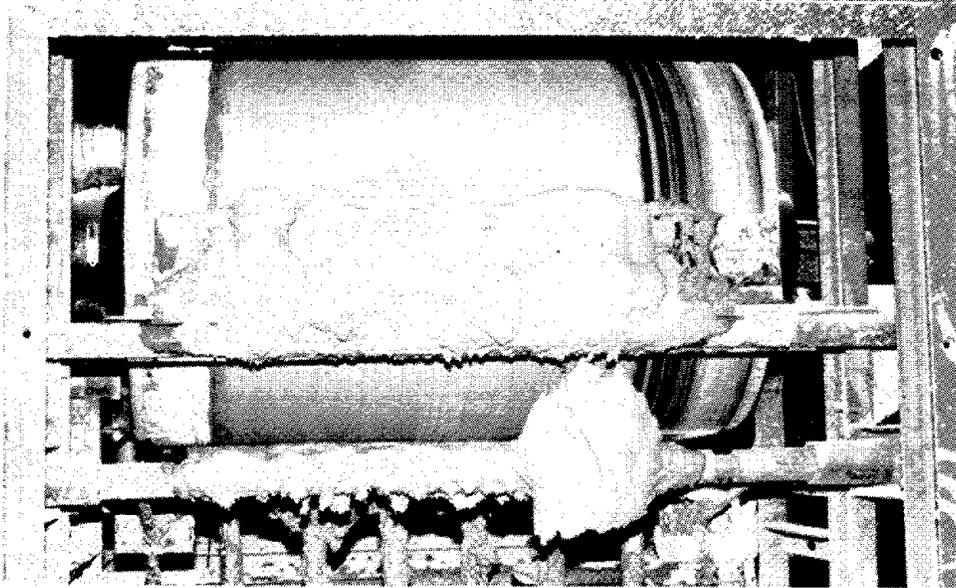


Figure A3. Lopper Blade Engaged



Figure A4. Action 2 Engaged

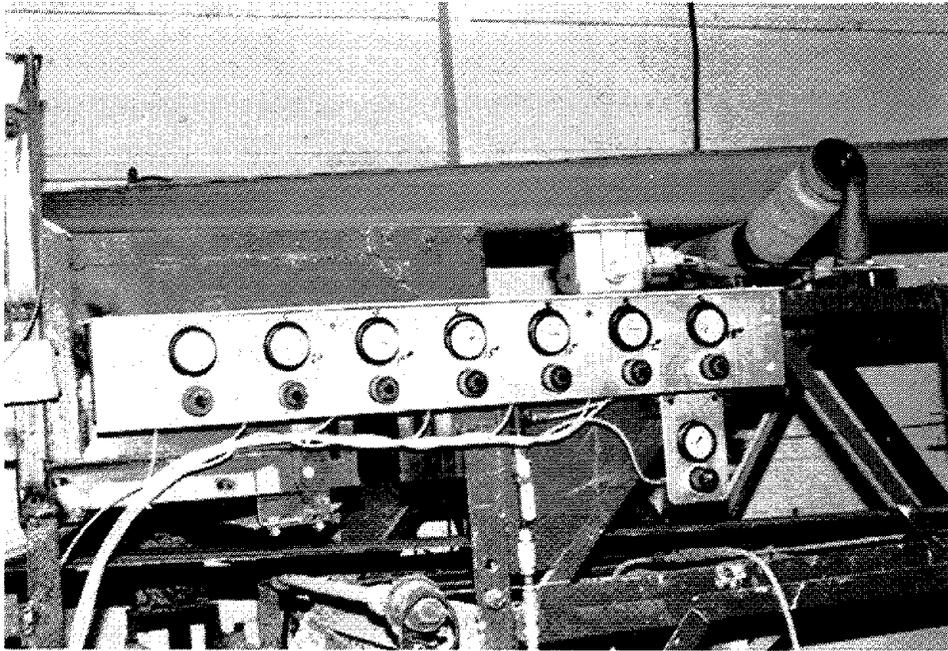


Figure A5. Pressure Regulators

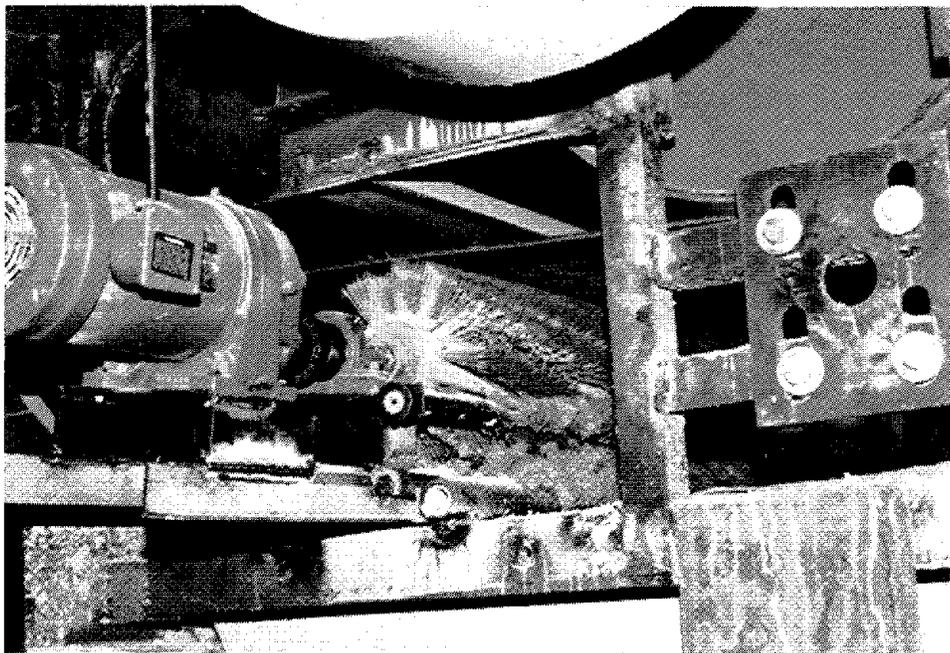


Figure A6. Action 3 Engaged

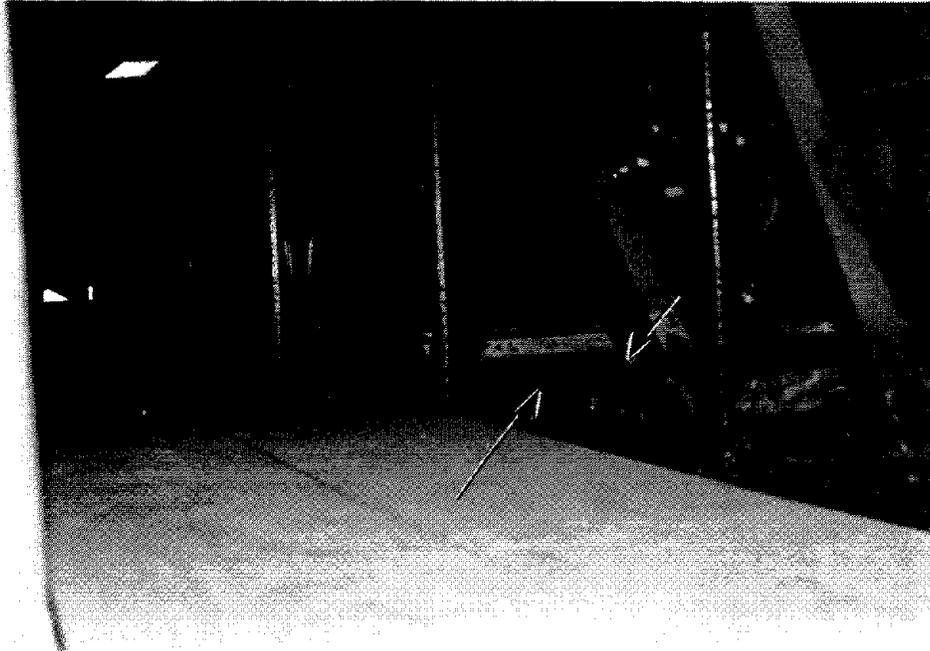


Figure A7. Collector Pans Installed



Figure A8. Sampling Area for Material Carried Over to Top Strand

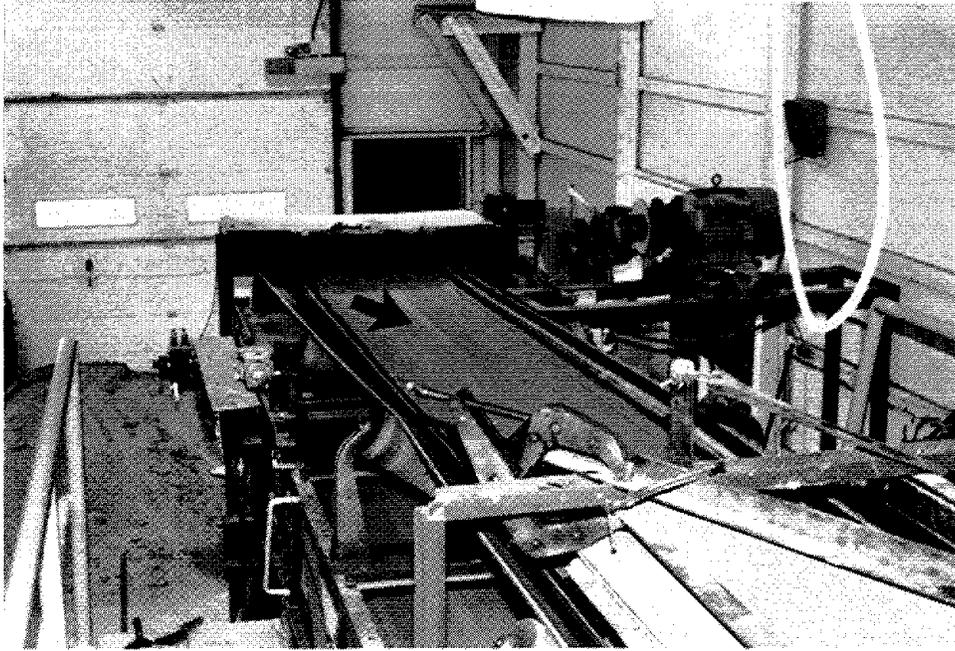


Figure A9. Sampling Area for the Load Material

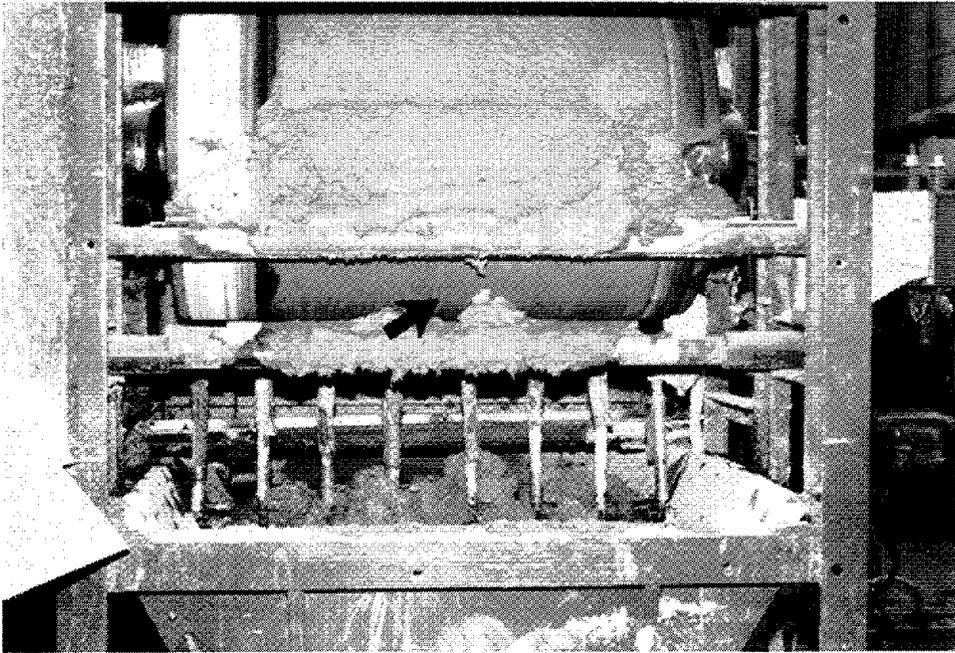


Figure A10. Sampling Area for Material Removed by Lopper



Figure A11. Sampling Area for Material Carried Back

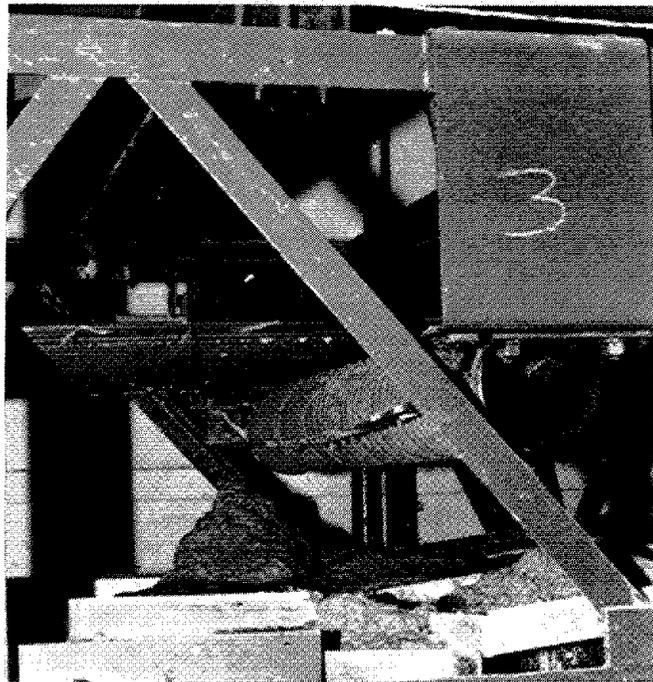


Figure A12. Station 3 Spillage Sampling Area

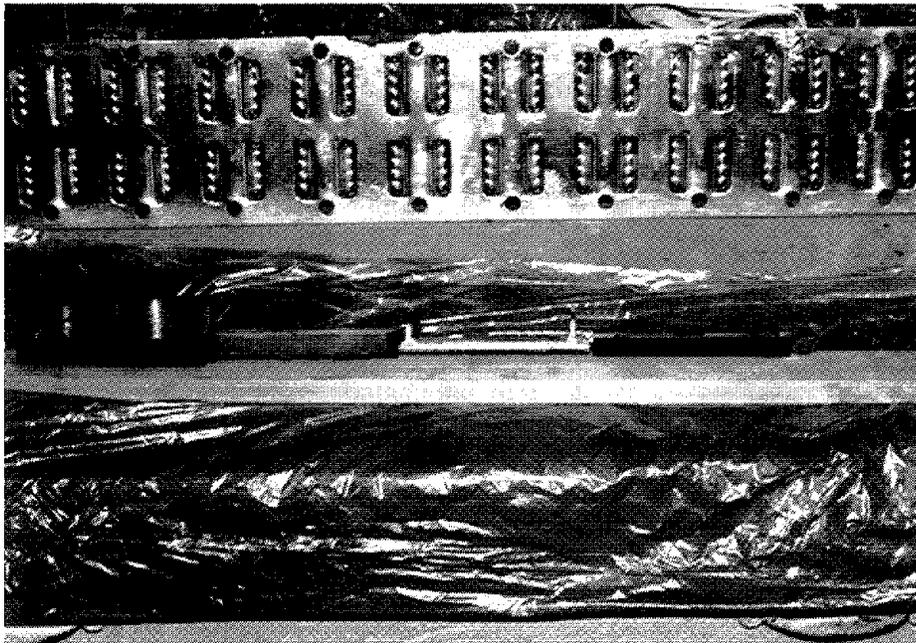


Figure A13. Tested Blades

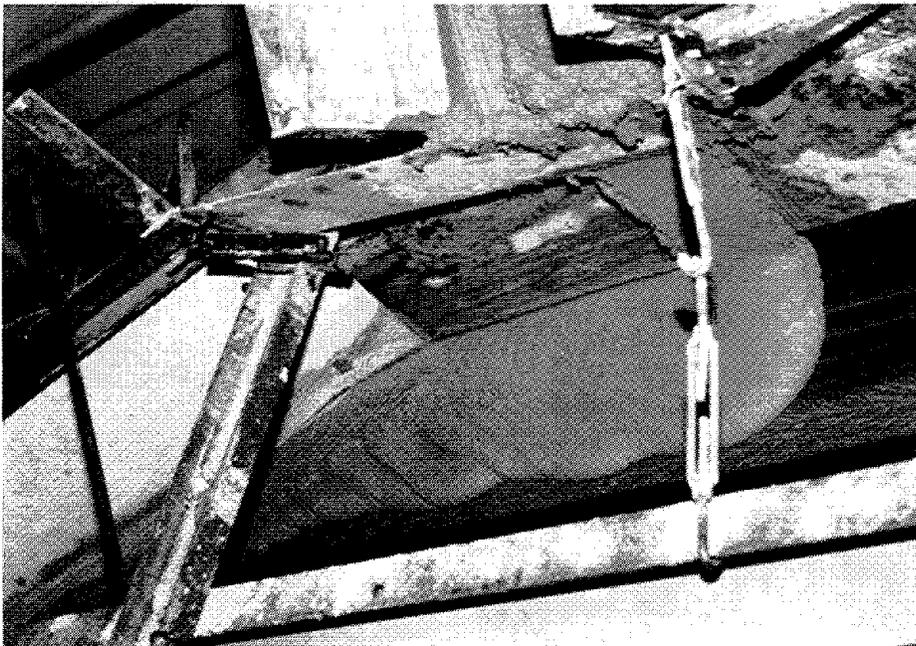


Figure A14. Spreader

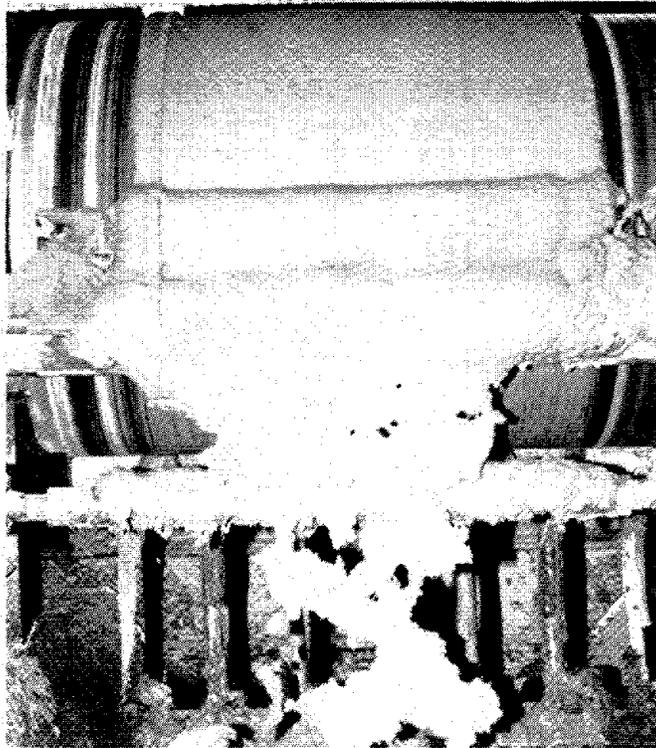


Figure A15. Lopper Engaged

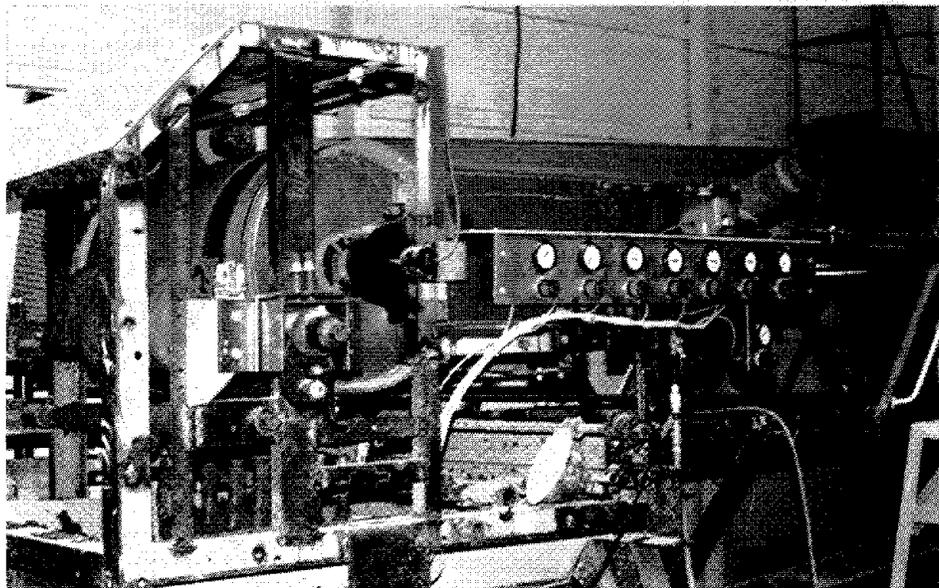


Figure A16. Test Apparatus in Operation



Figure A17. Sampling Area for Test Blade 4

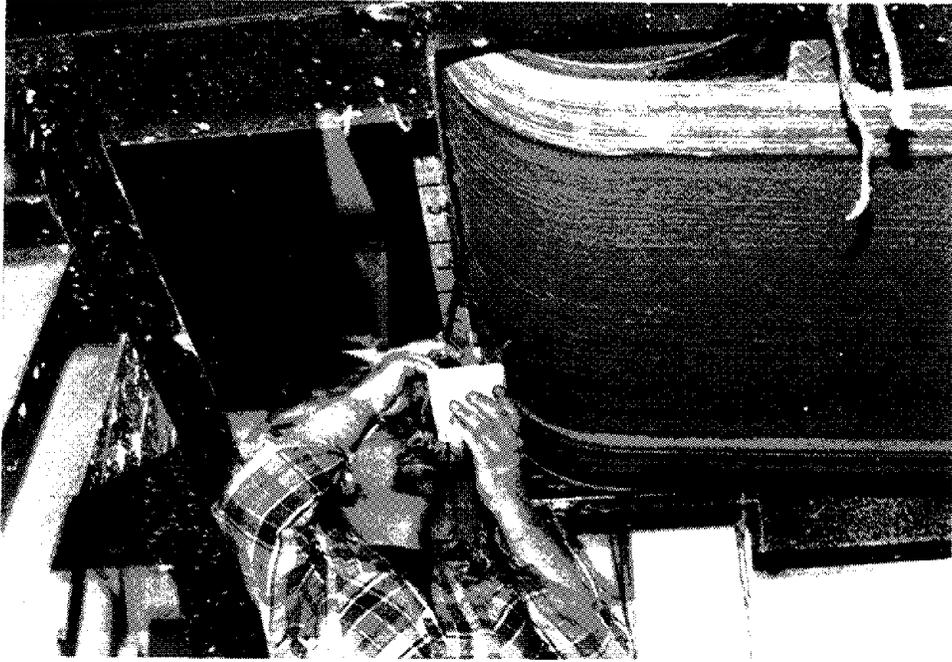


Figure A17. Sampling Area for Test Blade 4

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