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GUARDING OF BELT CONVEYORS

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Foreword

Trough and flat belt conveyors account for approximately 40 percent of all accidents which occur on conveyors. Over the years considerable research has been devoted to the safe operation of these machines and methods have been devised which ensure that the principal dangerous parts can be satisfactorily guarded.

In spite of this progress, there are still too many accidents and therefore much more attention must be given to the application of these principles if accidents are to be prevented.

The object of this booklet is to assist industry to become more aware of the hazards involved by highlighting the risk areas, and defining and illustrating the guarding methods which will assist management in meeting their statutory responsibilities under the Machinery Act 1950 and to improve the safety of persons working with these types of machines.

(A Ruffell)
Chief Inspector of Factories

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DEFINITIONS

Flat belt conveyor: A conveyor having a moving flat belt carried on free-running rollers

Troughed belt conveyor: A conveyor composed of a moving belt carried on horizontal

Head pulley: The terminal pulley at the discharge end of the conveyor.

Tail pulley: The terminal pulley at the loading end of the conveyor.

Snub pulley: The pulley used to increase the arc of contact of the belt on the driving pulley.

Carrying idler: Idler roller which supports the loaded belt.

Return idler: Idler roller which supports the empty side of the belt.

Bend pulley: A pulley used to change the direction of the belt in a vertical plane.

Take-up pulley: The tensioning pulley used in the take-up device which applies tension to the belt and reduces slack.

MACHINERY ACT 1950

Over the years conveyors have become firmly established aids in an expanding materials handling industry. It is not always appreciated that they may contain a number of dangerous parts. To protect personnel, either employed or working in establishments where machinery is used, the Machinery Act 1950 was introduced.

This Act, in making provision for the safety of persons employed or working in any place in which machinery is used, places a responsibility on the owners of the machinery to ensure that every moving part of the prime mover, every part of any transmission, and every dangerous part of any machine is securely fenced unless safe by position or construction.

The requirements can be met in respect of conveyors by:

(a) Complete enclosure of the moving parts of the prime mover and all transmission machinery.

(b Attention to details of design and construction to eliminate dangerous parts;

Where construction will not eliminate dangerous parts, guards and/or other devices should be fitted which will prevent a worker from becoming trapped or injured by the dangerous parts.

No conveying appliance shall at any time be left in charge or control of any person under 18 years of age. The owner of the machinery shall ensure that no person works at or with the machinery unless he has been fully instructed as to the dangers arising in connection with the machinery. The worker must receive sufficient training or be adequately supervised by a person having a thorough knowledge and experience of the machinery.

ACCIDENT CAUSES AND DANGEROUS PARTS

Records show that one-third of all flat belt and troughed conveyor accidents are associated with the clearing of blockages, and an equal number occur during normal unloading operations. The parts associated with accidents and which should therefore be considered as being potentially dangerous are listed below. Some of these are illustrated in fig. I which depicts a simple flat belt conveyor.

(a) Nips between the conveyor belt and discharge plate or discharge roller.

(b) Nips between the conveyor belt and pulleys as occurs at head pulleys, tail pulleys, drive pulleys, bend pulleys, tension pulleys,

etc.

(c) Nips between the conveyor belt and idler pulleys where the upward movement of the belt away from the pulley is restricted as occurs where skirt plates are fitted or where the slope of the belt changes.

(d) Nips between the conveyor belt and conveyor frame or between belt pulleys and conveyor frame.

(e) Projecting shafting.

(f) Belt cleats and belt fasteners.

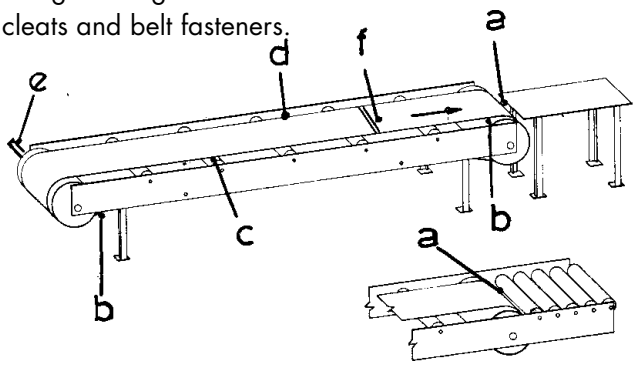

Fig. I : Dangerous parts of conveyors.

CONVEYOR GUARDING

General

Individual electric motors are usually completely enclosed except for the shaft end to which the transmission pulley, sprocket, or coupling is secured. Good design of the transmission guard will enclose the shaft end as well as the transmission. Transmission should be securely fenced and in this connection reference should be made to the department's leaflet *The Guarding of Transmission Machinery.*

There can be a considerable number of potentially dangerous parts on any belt conveyor and the only way to obtain secure fencing is by total enclosure of these parts. Alternatively, adequate safety from the dangerous parts may be achieved if the conveyor is situated in such a position that it is beyond the reasonable reach of any person employed or working in the vicinity of the conveyor.

Where secure fencing or positional safety is not possible, due to the nature of the machine or operation, the only practical way of dealing

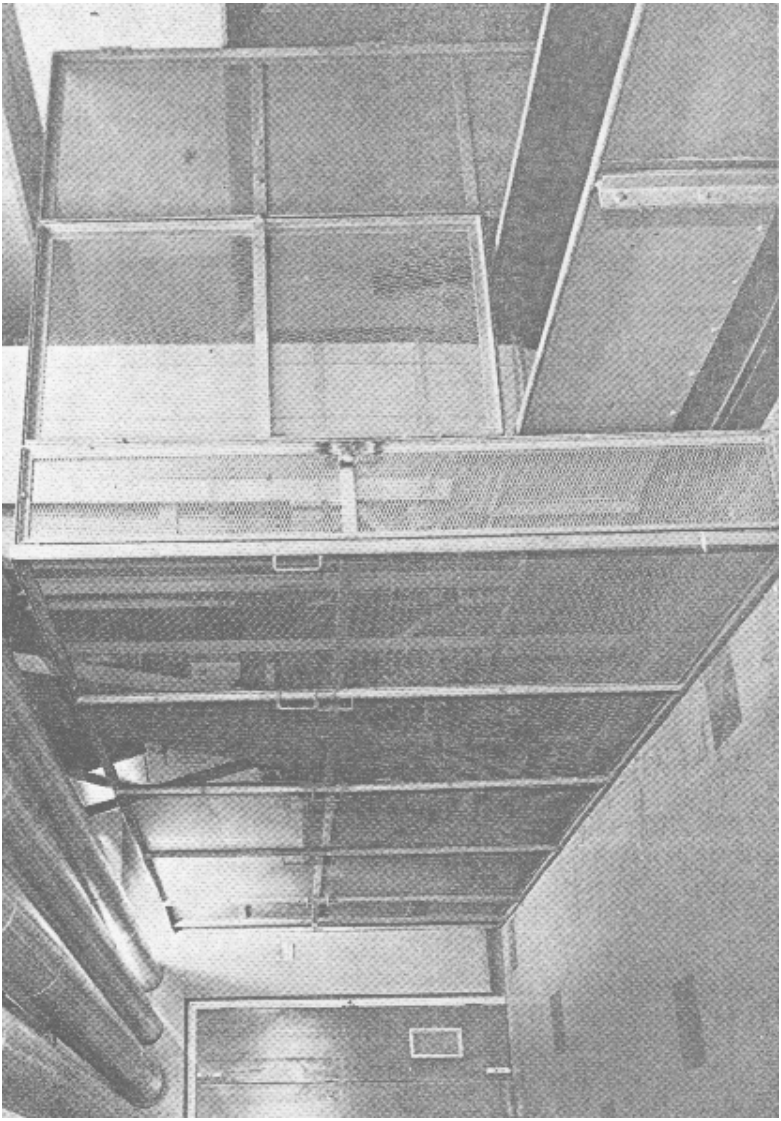

Fig. 2: Secure fencing of primary machinery and driving pulleys

with the dangerous parts may be to fit devices which will automatically prevent workers being trapped or injured.

In the installation shown in fig. 2 the guards are panel type which slot into the base structure and are secured by two top bolts. This arrangement gives a quick and easy method of removal when maintenance or adjustment is necessary.

Automatic dead weight belt adjustment gear as shown in figs. 3 and 4 must be securely fenced to prevent injury from falling weights in the event of a broken belt or other malfunction.

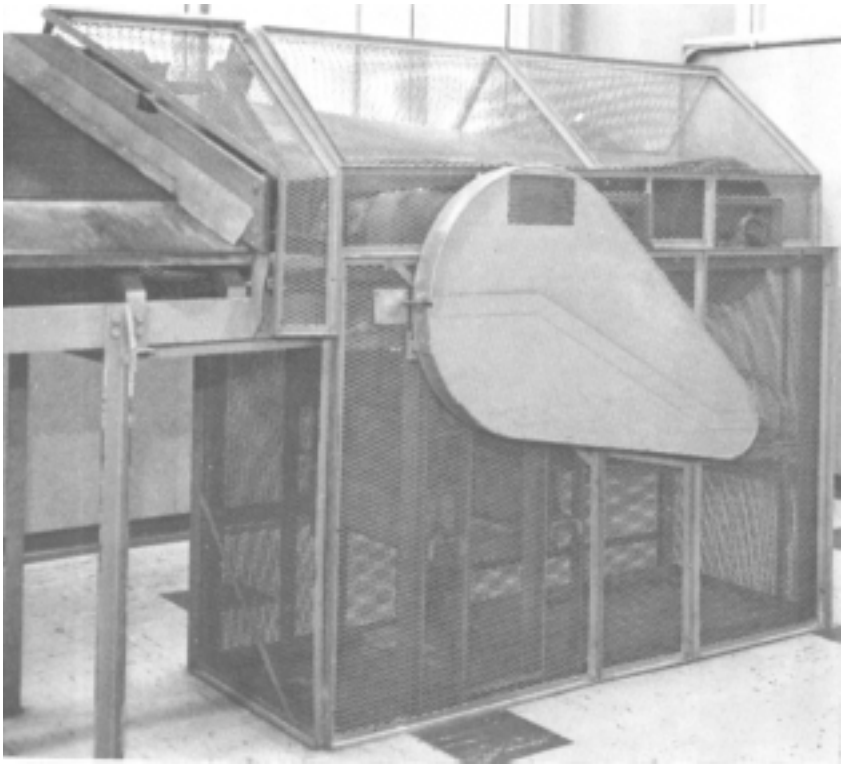

Fig.3: Secure fencing of head pulley, transmission and automatic belt tightening mechanism

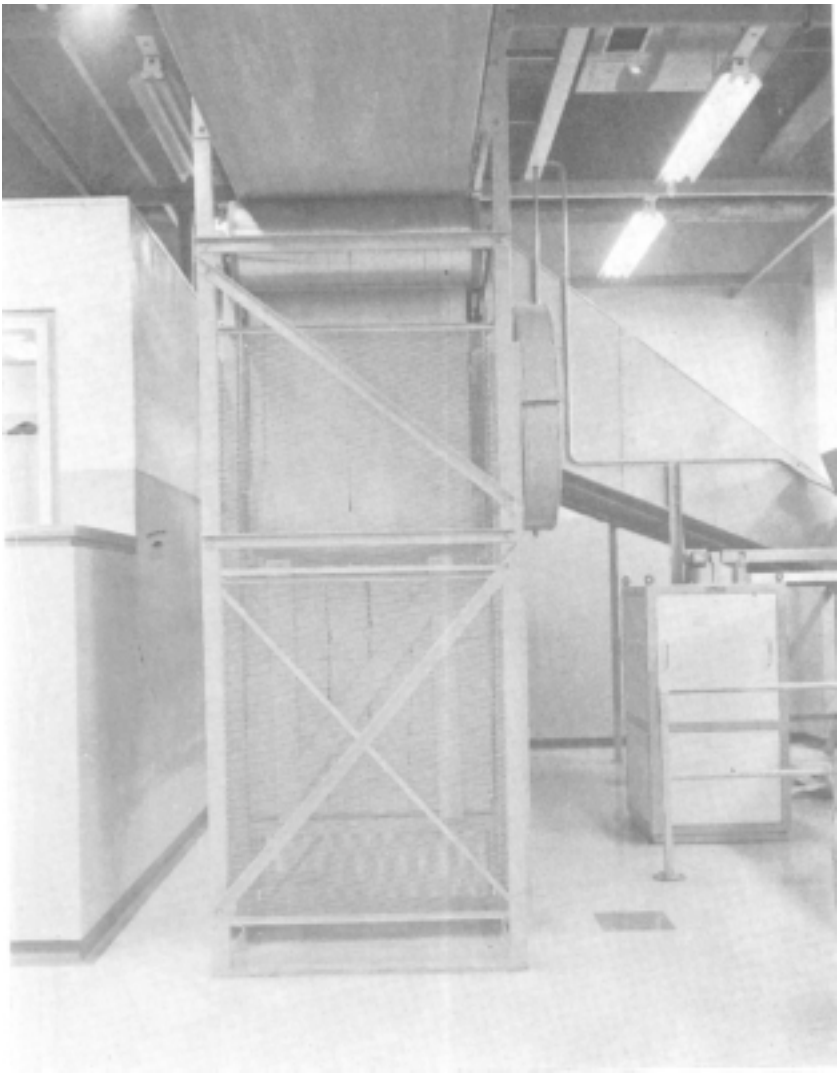

Fig. 4: Further example of secure fencing around an automatic weight tension mechanism.

Head pulley fencing

Dangerous parts such as inrunning nips between belts and head pulleys are required to be "securely fenced". The term "securely fenced" means that the dangerous parts must be so guarded that there is no longer a foreseeable risk of injury to persons employed or working on the premises, even a person who is careless or inattentive.

This requirement can be achieved by completely enclosing the dangerous parts with rigid guards of suitable construction.

In some cases complete enclosure may present practical problems, for example, where materials or packages being conveyed need to be manually removed from the discharge (head pulley) end of the conveyor. In this situation, alternative methods of guarding must be employed to effectively prevent any person from coming into contact with the dangerous parts.

Care must always be taken to ensure that whatever method of guarding is employed it must afford the same degree of protection as mentioned in the opening paragraph of this section.

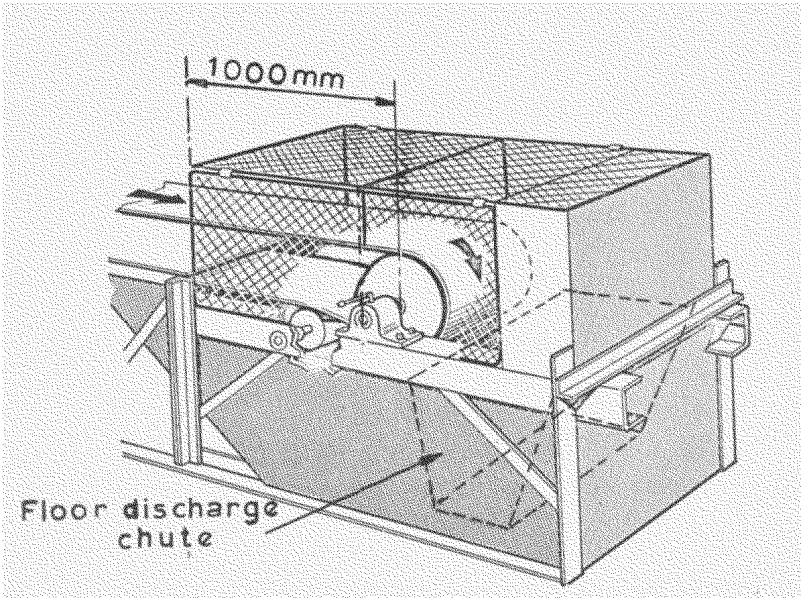

Fig. 5: Typical head pulley secure fencing.

When using the type of secure fencing shown in fig. 5 the guard should extend a sufficient distance (1000 mm minimum) from the pulley axis to prevent workers reaching through the guard opening and reaching the inrunning nip.

Tail pulley fencing

The inrunning nip between the conveyor belt and the tail pulley is on the return run of the belt and although this may be less accessible than that of the head pulley nip it is responsible for about 10 percent of belt pulley accidents. Where this nip is within reach, guards shall be provided on each side of the conveyor framework to prevent access to the nip from the sides.

Guarding on the underside of the conveyor framework may also be required where there is access from below, Any such guarding shall extend 1000 mm from the pulley axis, fig. 6.

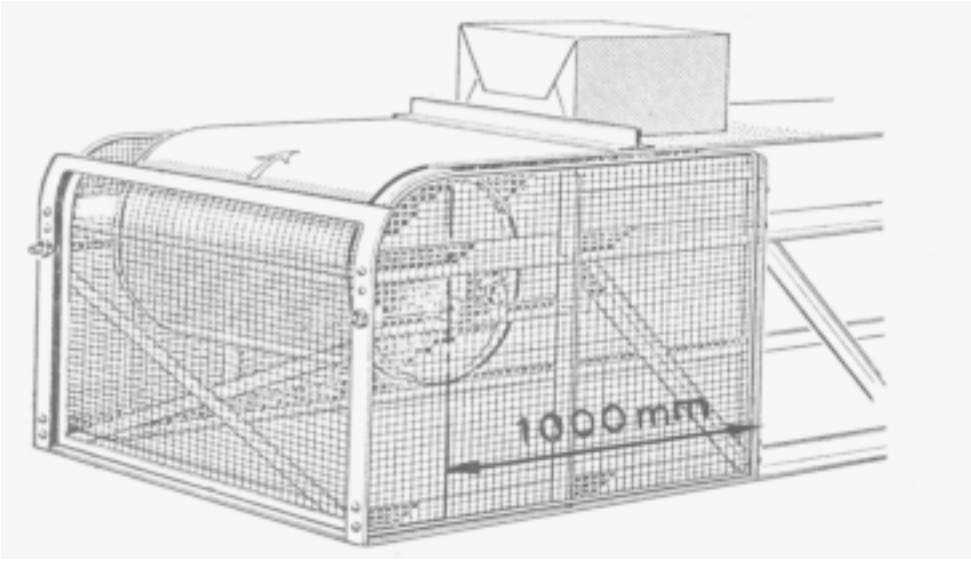

Fig. 6: Secure fencing of tail pulley.

Any secure fencing requirements shall take into consideration possible nips between the pulley and/or belt and the framework of the conveyor. Correct design of fencing can safeguard these nip points.

Provision may be made to clean underneath the conveyor and for this purpose a gap (150 mm maximum) between the floor and the guard may be allowed provided that the inrunning nip is beyond "reasonable reach" or some form of obstruction or barrier preventing access to the nip is fitted.

Note: "Reasonable reach" is defined in the department's booklet *Ergonomics o f Machine Guarding.*

Where it is not possible to prevent material being accidentally dropped onto the return run of the belt a suitable belt scraper should be installed to remove this material.

Fencing of trippers and sweeps

Where mechanisms are employed such as discharge sweeps and travelling trippers, secure fencing of the plough and the pulleys of the tripper should be provided.

The fencing must be such that no worker can reach any dangerous part or inrunning nip. Figs. 7 and 8 illustrate the required type of guarding. In the case of the travelling tripper, toe guards must be fitted to all wheels which are likely to be a source of danger to personnel working in the area.

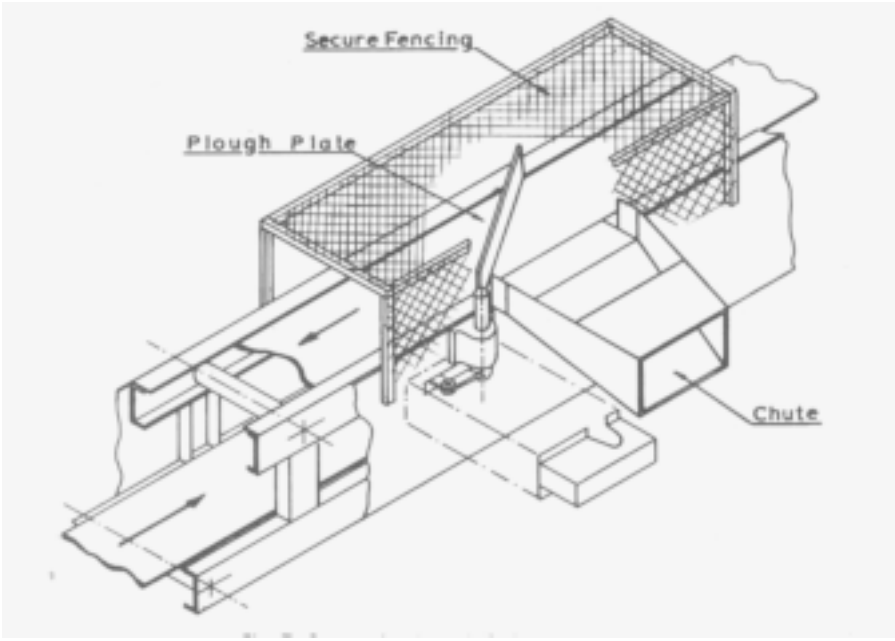

Fig. 7: Secure fencing of discharge sweep.

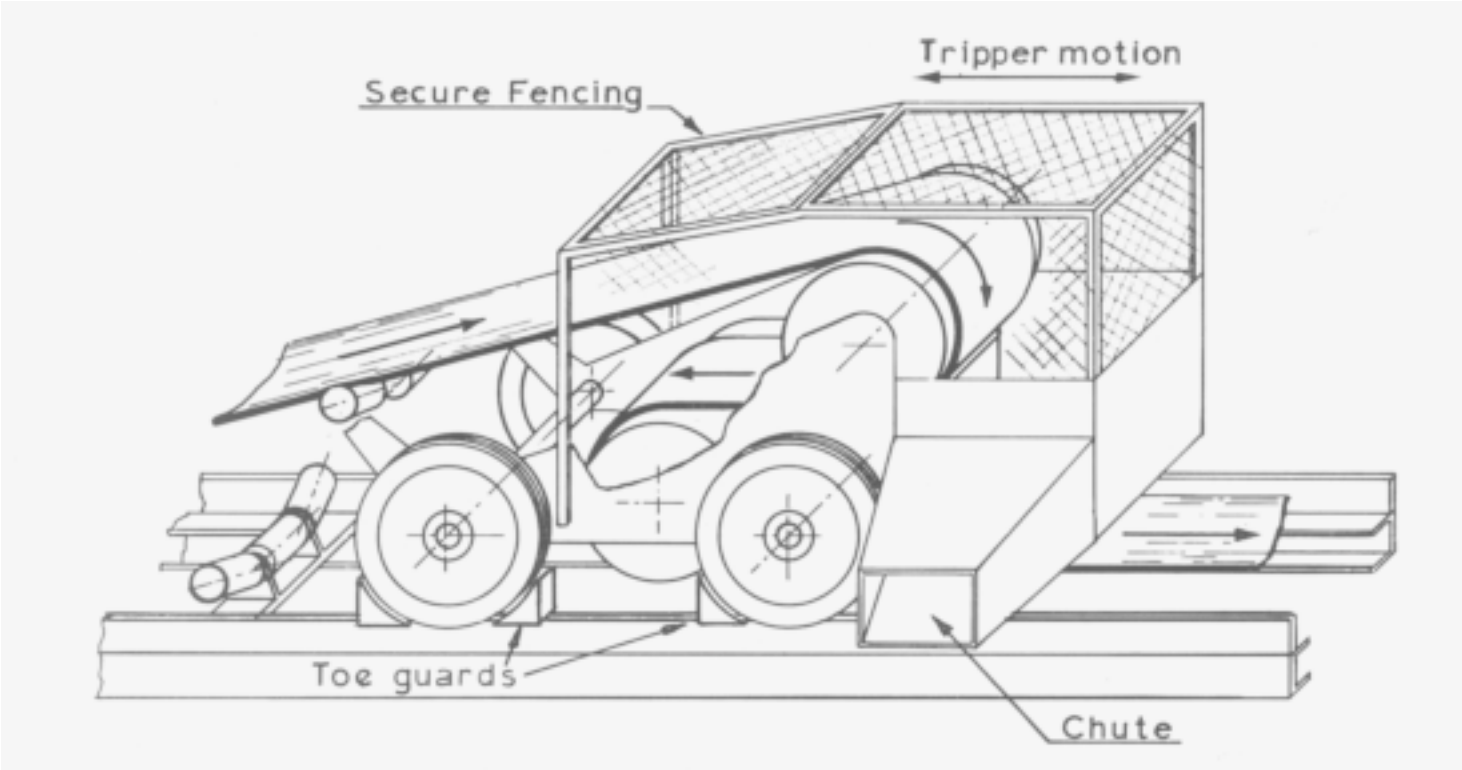

Fig.8 Secure fencing of travelling tripper

Conveyor discharge nips

Where discharge is to a roller conveyor, the provision of a "pop-out" roller, as illustrated in fig. 9 (a) and 9 (b), will eliminate an otherwise dangerous part. If the operator's hand is dragged into the nip between the belt and first roller, the latter is automatically displaced. If necessary a lightly tensioned spring may be used to retain the roller in place during normal operation.

The discharge roller conveyor framework should be wider than that of the main conveyor pulley to prevent the possibility of a nip hazard between the framework and the pulley.

Fig. 9 (a): "Pop-out" roller.

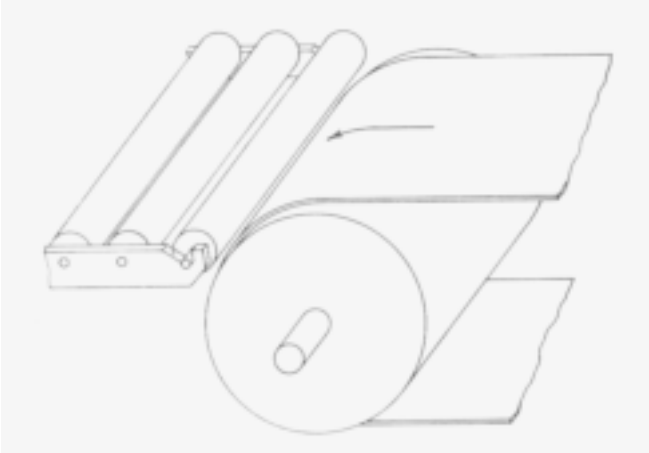

Fig. 9 (b).

Where discharge is to a discharge plate the provision of a pivoted "gap plate" as illustrated in fig. 10 (a) and 10 (b) will eliminate a potential hazard.

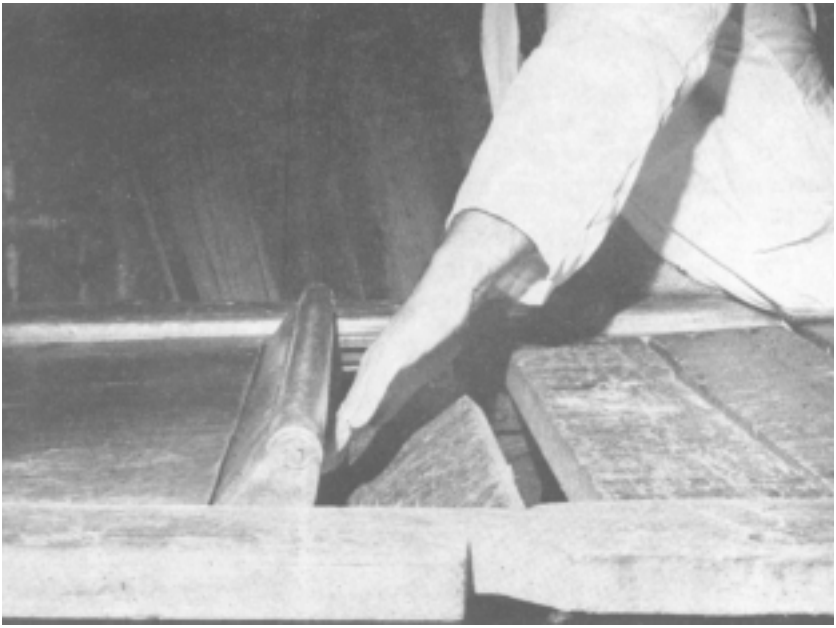

Fig. 10 (a): Pivoted "gap plate".

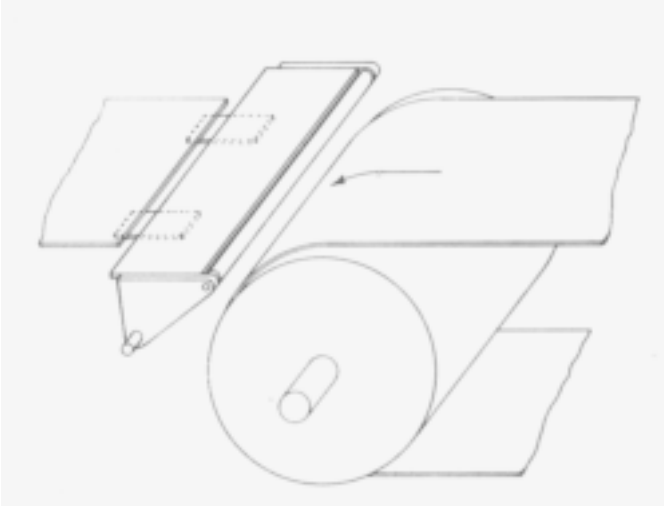

Fig. 10 (b)

The provision of an electrical interlock to stop the conveyor in the event of displacement of the gap "plate" or "pop-out" roller could also prevent possible injury caused by the articles carried on the conveyor.

Idler rollers

It should not be assumed that all idler rollers are dangerous, but where the upward movement of the belt is restricted, as occurs on some trough conveyors, or where belts are fitted with skirt plates reaching down to the belt, dangerous nips between the belt and the idler rollers are possible and must be guarded.

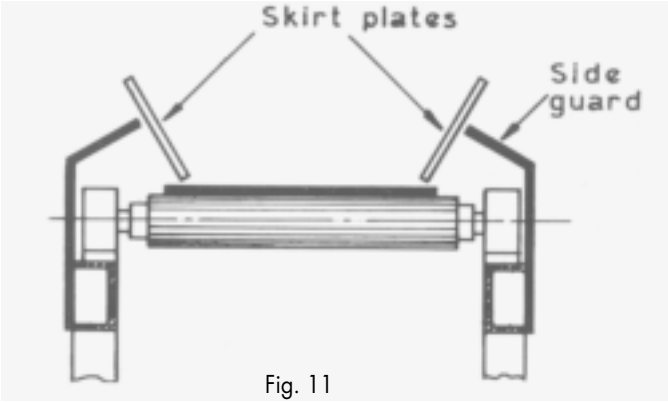

Fig. 11

Fig. 11 illustrates the type of side guarding which will prevent access to the nips between the belt and the idler rollers when the upward movement of the belt is restricted by the fitting of skirt plates.

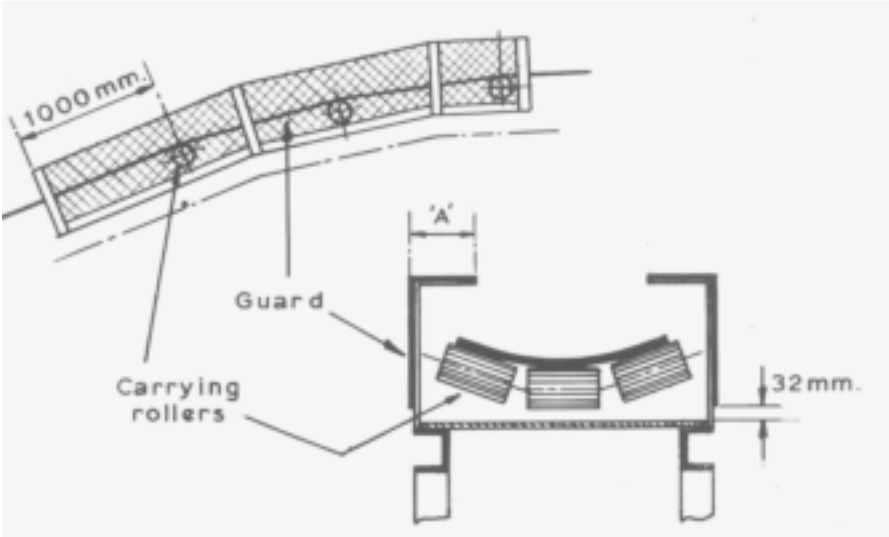

Fig.12.

At bends or at positions where directional changes to the belt take place the loading between the belt and the idler rollers increases. Where these areas are within reasonable reach secure fencing of the idler roller nips will be necessary. (See fig. 12.)

The extent of guarding (i.e. height and horizontal projection "A" of the guard) will be governed by the size of the load and the position of the conveyor. Reference should be made to the department's booklet *The Ergonomics of Machine Guarding.*

A maximum gap of 32 mm may be allowed at the lower edge of the guard for the removal of spillage if required.

Belt and pulley nip guards

When practical considerations preclude total enclosure of the head pulley, a nip guard of the type illustrated in fig. 13 may be used.

It should be noted that such devices should only be used as a last resort and secure fencing must be provided wherever possible unless the dangerous part is safe by position or construction.

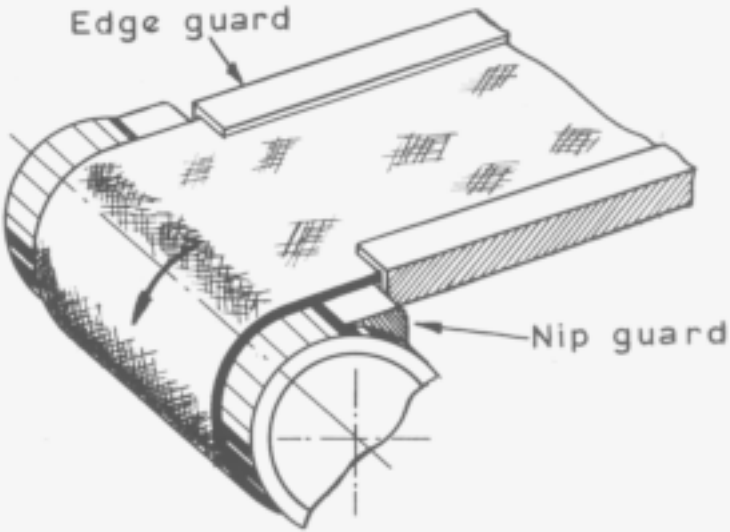

Fig.13.

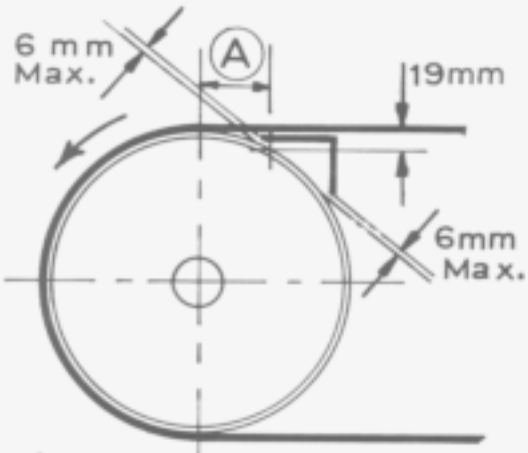

Fig. 14.

Fig. 13 shows a nip guard in a position where it prevents access to the nip between the conveyor belt and the head pulley. This suggested form of construction consists of an "angle iron" strip fitted as close to the pulley as possible. Where this type of guard is fitted it should be of sufficient length to be effective should the belt "wander" to either side of the pulley.

Where the sides of the belt constitute a hazard to workers, side or edge guards shall be fitted.

If the conveyor is reversible, then nip guards should be fitted to both the upper and lower nips of both the head and tail pulleys if these are accessible. The position of the dangerous nip between the pulley and the belt may be determined by drawing a line parallel to, and 19 mm beneath, the underside of the belt. The point where this line contacts the surface of the pulley may be assumed to be the danger point. If a finger is inserted beyond this point it will be drawn into the nip. (See dimension "A", fig. 14.)

THIS AREA MUST BE COMPLETELY ENCLOSED.

Where the pulley is adjustable, for the purpose of belt tensioning, the nip guard shall also be adjustable in order to retain the correct minimum clearance between the guard and the pulley (6 mm).

Other pulleys

In general, the principles outlined for head and tail pulleys should also be applied to the guarding of other pulleys under tension. Where pulleys of this nature are installed on the return run of the belt and they are within reasonable reach, guarding, as shown in figs. 15 and 16, would be satisfactory.

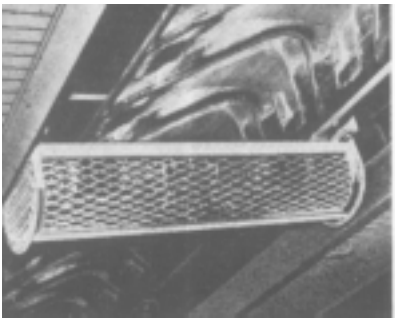

Fig. 15.

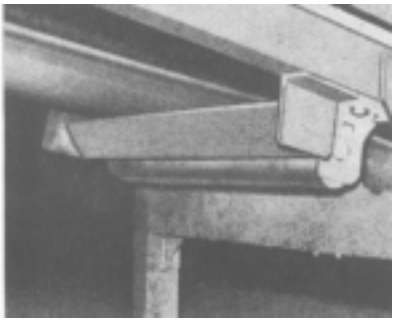

Fig. 16.

Projecting shafting

Shafting is dangerous when in motion. Experience has proved this not only where there are projections but also with smooth shafting. Shafting should therefore be securely fenced unless it is safe by position.

Belt fasteners and cleats

Where belt ends are joined by belt fasteners the joint will be more dangerous than the remainder of the belt. For this reason it is preferable to use a continuous belt rather than to join belt ends with belt fasteners.

Belt cleats are frequently necessary on inclined conveyors to prevent the packages carried from slipping back down the belt. Where the belt is fitted with cleats the fitting of a "pop out" roller or pivoted "gap plate" may not provide protection. Where this is the case side fencing complying with reasonable reach principles is necessary.

Nips may also occur between belt cleats and fixed parts of the conveyor framework and these will need to be either guarded or otherwise eliminated.

Nips between framework and moving parts

These types of dangerous parts can usually be eliminated at the design stage. Small details of design, such as leaving adequate clearances, can overcome a number of these dangers. Designers should be alert to possible nips between belt pulleys, belt idlers, and/or belts and conveyor framework and ensure that sufficient clearance is provided. Panelled enclosure of the conveyor framework may be necessary in some cases.

Reversible conveyors

Where it is possible to reverse the direction of travel of a flat belt conveyor, guards should be provided which will be effective regardless of the direction in which the conveyor is moving.

Special considerations

Section 19 (a) of the Machinery Act prohibits cleaning, examination, lubrication, or adjustment of machinery in motion whereby any person may be exposed to risk of injury from any moving part of, that machinery or any adjacent machinery.

The difficulties associated with frequent removal of guards and the continual stopping for cleaning purposes may be overcome by using hinged guards which allow access. Such hinged guards should be fitted

with cam operated switches to stop the machinery and prevent starting while the guards are swung out of position. (Refer also to the section dealing with stopping and starting devices, pages 22 and 23.)

Where the distance between the top and bottom belt exceeds 450 mm and the opening between them is unobstructed and within reasonable reach, then side fencing shall be fitted

CONVEYOR SAFETY

Access

Where it is necessary to cross a conveyor, suitable steps, platforms, and hand rails should be provided for this purpose.

Hand rails and intermediate rails should be fitted to all sloping gangways. Gangways from which a person is likely to fall should be provided with guard rails.

Top rails should be at a height not less than 1000 mm measured vertically from the nose of the step and not less than 1000 mm above any landing. A toe board of not less than 150 mm high should be provided at floor level on gangways. These safety measures should also be extended to hoppers or similar loading positions which are above conveyors, or at floor level. Where access is allowed underneath a conveyor it should be guarded if:

(a) Any dangerous part is within 2.4 m measured vertically from a working area or walk way.

(b) Where the conveyed material is of such nature that it could cause injury if dislodged.

(c) If dust or other substance is likely to be carried around on the return run of the belt and drop on persons passing underneath.

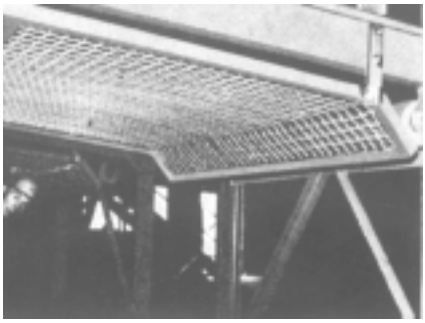

Fig. 17: Head guard.

Where dust or similar materials are being conveyed, the head guard shall be of sheet material shaped in such a manner that any overspill is directed to either side of the access way.

Interlock mechanisms

Conveyor systems which are left to operate for some time unattended should be fitted with an electrical or mechanical device which automatically stops them when the hopper, or other part which it feeds, has been blocked or stopped. This ensures that the conveyor system cannot receive additional loads.

Similarly, where two or more conveyors operate in series, the controls should be so designed that if one conveyor is stopped, all the conveyors feeding one another will stop automatically.

Lockout systems

Steps should be taken to prevent inadvertent starting of the conveyor while maintenance is taking place by personnel working in areas remote from the main control switch or switches.

The ideal method employed is to use lockable control switches whereby several positions are available for padlocks. Each person involved in activities associated with the equipment secures his own personal padlock to prevent operation of the switch during the period that work is taking place.

Hanging "hold" cards over switches and removing fuses are not foolproof practices for ensuring safety of personnel.

Starting and stopping devices

Provision should be made on all conveyors for operatives to stop the machinery quickly in the event of an emergency.

On short systems, or where several persons are working in the immediate vicinity, it may only be necessary to provide switches at a few suitable stations provided they are convenient to the operatives.

The following precautions should be observed:

- "STOP" switches must be provided at all loading and delivery positions.
- "STOP" controls should be provided which, when operated, have to be reset at that point before the main switch can be closed to restart the conveyor.
- Where possible, starting should be done from a position which enables the whole length of the conveyor to be seen.

- If the whole length cannot be seen, a warning device which sounds before the system is started is desirable.
- Where there is an overrun of the system, the provision of a braking device is desirable.
- All electrical apparatus should fail to safety.

When power is cut off, the conveyor must stop and remain stopped until power is restored. Either an electro-mechanical brake or anti-run back device may be used. This is especially important in consideration of inclined conveyors where the load if not restrained can cause motion in the reverse direction.

Troughed belt conveyors are mainly used for the transfer of bulk materials in large quantities over long distances which are infrequently supervised. It is not always practical or economical to situate stop buttons intermittently throughout the length of this type of conveyor nor does this system give maximum control. However, a properly installed trip or stop wire system will give substantial control.

Trip wires and switches, if used, should be non-resetting and the machinery should only be capable of being started from the main starter switch.

A trip wire system will not in any circumstances be accepted as a substitute for proper guarding. Its main function is to provide a facility whereby a conveyor may be stopped in the event of an emergency.

Maintenance

It is the responsibility of the owner of the equipment to ensure that the machinery is kept in a sound working condition, that safeguards are not removed, and that no person interferes with such safeguards to the detriment of operational safety.

It is essential that all guards and safety devices are checked periodically and a comprehensive inspection made of the whole installation.

Incorrect adjustment or worn machinery can be a source of danger to operatives working on or using the equipment.

The introduction of planned maintenance not only reduces the amount of "down-time" with consequential increase in production efficiency, but it also helps to reduce potential hazards.

Planned maintenance should take into account:

- General state of the conveyor mechanism including adjustment, belt tension, and belt centreing.
- Condition and efficiency of guards.

- Correct functioning of trip wires, interlocks, and switches.
- Cleanliness of conveyors and general housekeeping in the vicinity of the equipment.
- Lubrication of moving parts.

Lubrication

Lubrication of machinery should never be undertaken whilst the machinery is in motion, unless provision has been made to do so at a safe working position away from any dangerous moving parts.

Grouping of lubrication points so that they are readily accessible without removing guards is a distinct advantage and gives:

- Greater safety.
- Less likelihood of missing a point.
- Less time required to do the job.

Material build-up

If material builds up on belts and pulleys, it becomes a source of spillage and can cause the belt to run off its designed path with the possibility of the belt edges sustaining damage on the fixed structure. Manual removal of build-up should not, except in special circumstances, be carried out while the conveyor is in motion. If it is necessary to restrict or remove material build-up while the conveyor is moving, some form of mechanical means should be employed.

The most suitable device for cleaning depends upon the type of material being handled by the conveyor and could take the form of belt scrapers, pulley reapers, head pulley brushes, or vibrating pulleys.

Should the conveyor system be such that only manual methods of cleaning are possible, and must be conducted with the conveyor in motion, then an opening in the guard may be made through which cleaning tools can be admitted.

This opening should only be sufficient to allow the introduction of cleaning tools or rods, and prohibit access to the dangerous parts by any person Reasonable reach principles in accordance with the department's booklet *The Ergonomics of Machine Guarding* should be followed.

It is important that if any provision is made for the introduction of cleaning devices that the cleaning tools or rods are directed or guided in such a way that they cannot become wedged in any part of the moving machinery. Permanently fixed belt scrapers should be installed wherever possible.

Static build-up

In certain circumstances and with adverse conditions an explosion or fire could be created due to a build up of static electricity. Build up of electrical potential between the belt and earth may reach proportions which ultimately create a high voltage discharge spark.

In the presence of any combustible dust given off by the material being conveyed, ignition could take place.

Metal chains or brushes in contact with the belt, or the use of conductive rubber belts, where the charge can leak away, will eliminate this possibility.

Training and supervision

No matter how well guarded the conveyor may appear to be, any inexperienced person could, if not given the necessary training and supervision, be exposed to unnecessary risks.

Persons operating or using any conveyor should receive instructions and training not only in the requirements of the job but also in the functional and safety aspects of the machinery.

Instructions on the following points should be given:

- The recognition of dangerous parts and the necessity of the guards, reasons for stopping before cleaning, removal of rubbish, etc.
- The operation of stopping, starting, and interlock mechanisms, procedures involved prior to starting.
- The purpose of the conveyor and the load capability of the equipment.
- The operator's own responsibility concerning the use of safeguards.
- The use of proper hand tools for clearing of spillage (if necessary).
- The reporting of defects.
- Whom to contact if in trouble.

It is emphasised that it is the owner's responsibility to ensure that training and supervision are adequate and are properly planned. Failure to train or adequately supervise is an offence under the Machinery Act 1950.

For further information on the training of machine operators reference should be made to the department's pamphlet A Brief *Guide* to the *Training and Supervision* of *Machine* Operators.

Some safety rules for users of conveyors

Workers should be instructed in the following safe working habits:

(a) A conveyor should be used only for its designed purpose.

(b) Riding on conveyors is prohibited.

(c) No loose garment should be worn.

(d) Aisles and gangways should be kept clear, particularly at loading and unloading points. Spilled materials should be cleared away as soon as possible.

(e) No attempt should be made to clear or clean a moving conveyor, except where adequate provision is made for the job to be done safely. (See: "Removal of Build-up".)

(f) Operators should be made familiar with the location of all starting and stopping devices and other controls.

(g) In the event of trouble call the person designated by owners to deal with emergencies. Do not attempt repairs unless competent to do so and authorised by the owner.

(h) Guards or safety devices shall not be interfered with.

OTHER BOOKLETS AVAILABLE RELATING TO MACHINERY

The following booklets are available free of charge at any office of the Department of Labour.

Brief Guide to Training Machine Operators
Dangerous Parts of Machinery (Illustrated)
Dangerous Parts of Machinery to be Securely Fenced
Dough Brakes
Dough Dividing Machines
Drilling Machines
Ergonomics of Machine Guarding
Farm Safety Series No. — Guarding of Transmission Machinery
Firewood Saws — Secure Fencing
Granulators — -Guarding of
Hand Fed Platen Presses
Guarding of Heavy Power Presses
Horizontal Two Roll Mill
Lathes — Safety Hints
Lifting Gear — For Users of
Metal Cutting Guillotines
Mincers
Mobile Legging Tables
Guarding of Overhand Planers
Paper Cutting Guillotines
Portable Grain Auger Guarding
Press Brakes
Presses — Hydraulic
Presses — Punch and Forming No. I
Presses — Punch and Forming No. 2
Pneumatic Presses — Small
Safe Use of Machinery
Sheeps Head Splitting Machines — Guarding of