Skillings' Mining Review

REPRINTED FROM
DEC. 13, 1980
Vol. 69 No. 50
ESTABLISHED 1912

PUBLISHED EVERY SATURDAY MORNING

Shiftable and Overland Belt Conveyor Systems in Strip Mining

by FRANK J. LOEFFLER, P.E. RONALD C. SMITH
REGIONAL MANAGER SALES MANAGER
ROBINS ENGINEERS & CONSTRUCTORS
HOUSTON, TEXAS

GREGORY A. VAKA
REGIONAL MANAGER
ROBINS ENGINEERS & CONSTRUCTORS
WHITTIER, CALIF.

View of tripper and spreading stacker at Washington Irrigation & Development's coal operation, Centralia, Wash.

BELT CONVEYORS ARE BEING USED TO HANDLE TOP soil, overburden and ore within many of today's strip mines. In addition, belt systems are being used more frequently in connecting the pit limits to the process point or rail loading area.

Many coal mining operations in the central U. S. frequently use a box cut or modified area mining technique. A wide range of equipment is employed with basic stripping operations performed by draglines or stripping shovels.

Generally, in areas where coal lies within 40 to 50 ft. from the surface, stripping shovels are used because of their speed of operation, while overburden depths of up to 150 ft. in some areas call for the use of large draglines. Because of the high overburden to coal ratios, bucket capacities of stripping equipment range upward to 180 cubic yards for shovels and 220 cubic yards for draglines.

Wheel excavators, scrapers, dozers, and front-end loaders are also used for overburden removal. Most commonly used are draglines and shovels with wheel excavators and pan scrapers applied in special situations. Bucketwheel excavators have been effective in areas where the overburden is more easily removed. Shovel and bucketwheel combinations are being successfully applied where conditions permit.

Coal mining operations in the western U. S. commonly use area mining techniques and/or some form of open pit mining where seams are thicker. Basic ore or coal stripping operations are performed by a wide range of equipment including shovels, draglines, scrapers, dozers and front-end loaders. Overburden thickness in some areas is extremely thin and spoil material can be moved by scrapers, dozers or front-end loaders. Generally, the overburden is considered thin when coal lies within 40 to 50 ft. of the surface.

Ore seams greater than 70 ft. thick present a unique set of problems to be analyzed. A greater emphasis must be placed on proper coal or ore loading, hauling and storing than on overburden removal procedures.

Overburden to coal ratios of 1:1 or less are not uncommon. There are mines in Wyoming with as many as 13 seams ranging from 4 to 93 ft. in thickness, situated sufficiently close stratigraphically to one another to permit stripping of all seams. Mining of the coal then progresses along a series of steps or benches situated at the level of each coal seam. When the coal outcrops along the top of a ridge, the lower seam is the thickest and has the greatest B.t.u. value. This seam is mined first with progressive benching of overlying seams as encountered.

The stripping ratio compares overburden thickness to coal thickness with the limit determined in most instances by the economical and physical limitations of the excavating equipment. Depending on the thickness, continuity, slope, quality of the coal seam, type, conditions of the overburden encountered, size of the mine area, and finally the dollar return per ton of coal mined, this ratio can be as high as 30:1 and still be a profitable operation.

BELT CONVEYOR USE IN STRIP MINING

Today belt conveyors are widely used for handling top soil, overburden, ore or coal, and also for transporting the ore or coal from the pit limit area to the process area. Depending upon the geology of the mine, belt conveyors often prove to be the most economical solution for any or all of the above haulage requirements. Some mines today use belt conveyors for haulage of all materials from or within the mine.

Starting first with top soil, a common application of a conveyor system for its removal would be as follows. A side shiftable conveyor would follow a bucketwheel excavator moving laterally with the pit development on the cleared bench. The shiftable conveyor discharges the reclaimed top soil onto an extendable conveyor situated on the perimeter of the pit proper. In turn, the top soil would then be discharged to a second side shiftable conveyor operating on top of the regraded spoil area.

The discharge and level spreading of the top soil from the conveyor would be accomplished through the use of a crawler or rail mounted tripper to a crawler-mounted spreading stacker, as shown in the illustration on the front cover.

Currently a system of this type is being utilized for reclamation purposes at Arch Mineral's Captain mine in Illinois.

Another important application for the use of shiftable conveyor systems is in the handling of overburden. The shiftable conveyor system operating on the upper bench would, like the top soil system, have two shifting conveyors and one extendable conveyor to transport the overburden from the active face around the pit limits to the spoil area side.

Again, a tripper and crawler-mounted stacker would be utilized to discharge and spread the overburden. However, the overburden would be deposited on the pit floor after the orebody has been removed.

A third application is for the actual handling of the coal or ore from the pit. This side shiftable conveyor system would receive the ore from the reclaiming machine and transport it, through the use of bench lift conveyors, continuously to the upper limits where it would be deposited onto an extendable collecting belt. Frequently, the collecting belt will convey the ore to a process plant or rail loadout system. Depending on the actual site of the pit and the plant, an overland conveyor is often used.

EQUIPMENT USED FOR STRIPPING

The three main types of equipment used for stripping operations in conjunction with a belt conveyor system are draglines, power shovels, and bucketwheel excavators. Each excavator type requires its own method of transferring the material onto the belt conveyor system.

In the case of the dragline, it is necessary to provide a target hopper that will enable the operator to rapidly discharge his payload without having to precisely line up the discharge. Also, because draglines tend to produce large lump sizes, it is often necessary to equip this hopper with an apron feeder discharging into a crusher to reduce the material to about one-third the width of the receiving belt. These hoppers are generally crawler-mounted or are equipped with walking legs and

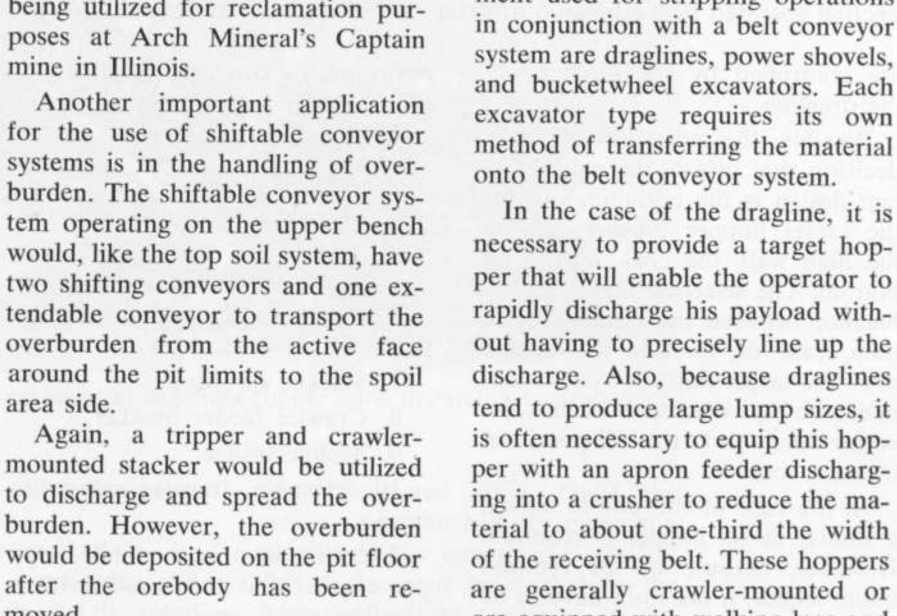

Fig. 1 — Traveling impact section used at Washington Irrigation & Development's coal operation at Centralia, Wash.

Fig. 2 — Cable reel car, bandwagon, wheel excavator and traveling impact section operated by Washington Irrigation & Development at Centralia, Wash.

are controlled by the operator of the dragline.

Possibly, the most difficult basic decision that affects the entire system design is the optimum site for the target hopper crusher unit-on the high wall, the coal, or the pit bottom. The selection is based on a balance between the dragline cycle time, ease of spotting the bucket over the target hopper, system maneuverability, conveyor incline, pit congestion, and the disposal of oversize rocks.

In the case of the power shovel, a similar target hopper is required. However, because of the reduced boom length, it does not have to be quite as large. A shovel system, like the dragline, may require a crusher to reduce the material to a conveyable size.

In the case of the bucketwheel, because the operator generally can control the size of the material, a crusher is not normally used. The bucketwheel, however, does require the use of a transfer conveyor or what is commonly called a bandwagon to transport the material to the shiftable system and is limited to relatively easy digging material. The bandwagon provides a flexible link between the excavator and the conveyor system, reducing the frequency of conveyor shifting.

AUXILIARY EQUIPMENT IN BELT SYSTEMS

The following listing, which is later described, outlines the various components needed to marry a belt system with the excavating equipment and provide a means of disposing of the conveyed product.

1. Mobile hopper and crusher.
2. Traveling impact section.
3. Cable reel car.
4. Elevating or bench lift conveyor.
5. Crawler-mounted bandwagon.
6. Crawler or rail-mounted tripper.
7. Stacker spreader.
8. Crawler feeder breaker.
9. Mobile bridge.
10. Movable transfer conveyor head.

The first item is a mobile hopper/crusher unit and is used with a dragline-type operation. Again, these hoppers are provided to supply a reasonable size target area for maximum operator efficiency and to permit crushing of the raw material before it is deposited onto the conveyor system.

Because a relatively high degree of maneuverability is desired, it is important to optimize the hopper orientation with respect to the dragline and some preference should be given to a walking device. While equivalent performance is possible with crawlers, the design is costly and more complex. Also the propel mechanism must have adequate strength, power, and stability to permit moves with a full hopper. If pitching seams or inclined operations are anticipated, consideration should be given to a leveling system because performance of crushers and feeders decreases rapidly with deviation from the horizontal.

The traveling impact section (Fig. 1) is used on a conveyor that requires a moving load point. This section has Garland type impact idlers that are used to absorb the energy produced by the free fall of large lumps of material. These impact sections are mounted on rails running parallel to the conveyor and include a hopper that is suitable for receiving the trajectory from another conveyor.

The cable reel car (Fig. 2) is used to provide power to the wheel excavator. The cable reel car also rides on the same rails as the impact section, and it supplies power to the stripping machine operating anywhere along the length of the conveyor.

The elevating conveyor (Fig. 3) is used to raise the material from the pit floor or lower bench to the upper pit limits. This conveyor can be skid-mounted or crawler-mounted, depending upon its size and the amount of lift and mobility required.

These conveyors are sometimes provided with cleated or Huggar belts to increase incline angle and shorten the length required to obtain the needed elevation. The length should be kept as small as possible because this affects the mobility of the stripping machine feeding the shiftable conveyor and also the amount of usable pit area.

The bandwagon is a crawler-mounted machine that is used to reduce the shifting interval time. This machine affords extra distance between the bucketwheel stripping machine and the shiftable conveyor. It has wide operating flexibility and can be operated from a position almost parallel with the shiftable belt to a position perpendicular to it. The length of the bandwagon determines how far the excavator can advance into the working face before it is necessary to move the side shiftable conveyor.

The crawler or rail-mounted tripper is used with the spreading stacker. It trips the material off the shiftable conveyor and discharges it onto the spreading stacker. A tripper of this type is also used to provide a moving transfer point that advances toward the working face feeding the second shiftable con-

Fig. 3—Bench lift conveyor at Nchanga copper mine in Zambia, central Africa.

veyor for the top soil and overburden systems.

The spreading stacker is employed to deposit overburden and/or the top soil back into the pit after the ore has been removed. The function of the machine is to discharge a pile of material in front of the side shiftable conveyor that can be further spread and compacted by the use of mobile equipment. The spreading stacker will then advance over the newly formed and compacted spoil to continue to fill in the mined pit. It is important that this machine have sufficient length to keep its crawlers away from the unstable face of the newly deposited and compacted spoil. Once the stacker has reached its maximum reach and the conveyor is shifted, the stacker can be moved to the back side of the conveyor to develop a second bench of material if required.

The crawler-mounted feeder/breaker is often used when mining coal or lignite, because it would not be practical to discharge large lumps directly onto the conveyor. The crawler-mounted feeder/breaker follows the excavating machine and is equipped with a discharge tail boom conveyor for flexibility in loading to the shiftable system.

Skillings' Mining Review

REPRINTED FROM
DEC. 20, 1980
Vol. 69 No. 51
ESTABLISHED 1912

Shiftable and Overland Belt Conveyor Systems in Strip Mining

THE MOBILE BRIDGE (FIG. 4) IS A SERIES OF crawler-mounted conveyors that have the ability to articulate and follow the stripping machine. This type of machine can be used in place of a bandwagon and basically serves the same function. It does, however, provide a greater operating length that would reduce the frequency of conveyor shifting. This crawler-mounted conveyor can also be used to replace the spreading stacker if it is equipped with a boom discharge section. Its main advantages are lower crawler loads and greater stability.

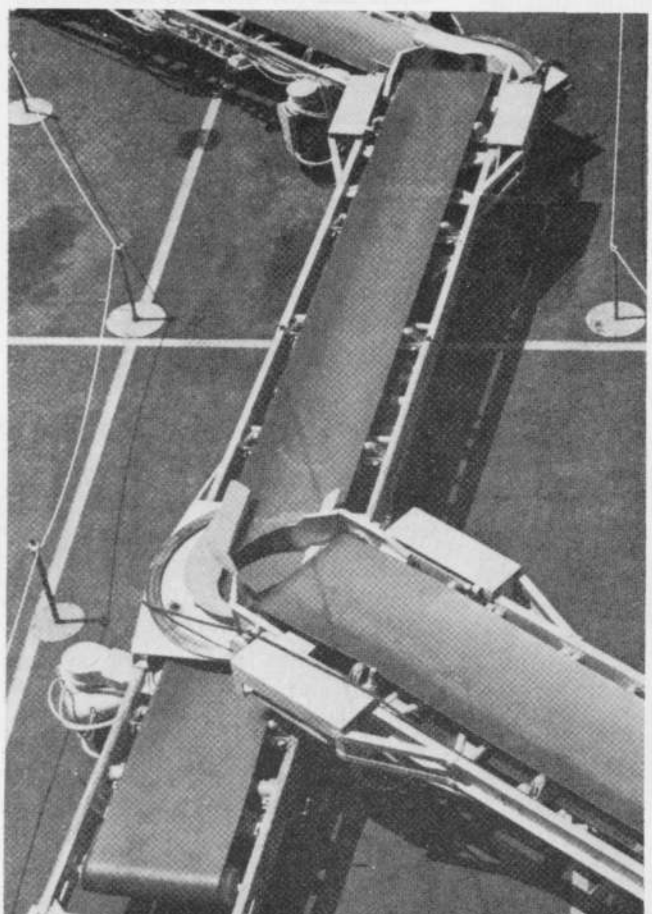

Fig. 4 — Mobile bridge.

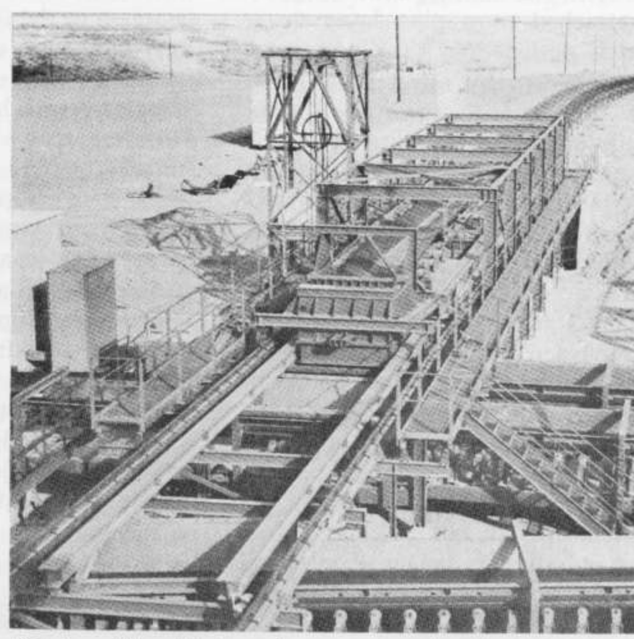

Fig. 5 — Movable transfer conveyor heads at Anaconda Copper Co.'s Twin Buttes mine in Arizona.

Movable transfer conveyor heads are used when it is necessary to transfer between two or more parallel conveyors that are far enough apart to rule out a normal chute transfer. These head ends, along with the take-up pulleys and accessory equipment, shuttle back and forth along the tracks and can be positioned precisely over any takeaway belts. This system allows rapid and accurate control of the flow of materials, and has the further advantage that transfers are made without causing the ore to break, because the drop from the feed conveyors to the take-away conveyors is only a few feet (Fig. 5).

SPECIAL FEATURES OF SHIFTABLE CONVEYOR BELTS

A shiftable conveyor system, features special head and tail sections that are provided with skids, rails or, in the case of very large systems, walking legs (Fig. 6) permitting lateral movement of the head and tail sections. These sections are generally designed with extremely rigid construction and feature shaft mounted drives to minimize misalignment. Special hydraulic belt takeup sections are incorporated into the head units. A typical head section is shown in Fig. 7.

The shifting is accomplished by the attachment of a shifting head to the rail. The shifting head (Fig. 8) is attached to a pipe layer dozer and is designed to raise and move the conveyor by offset traverse by the dozer. The conveyor is generally shifted a distance of 2 to 3 ft. per pass at a speed of about 350 to 500 f.p.m. Frequently, two tractors in tandem about 100 to 200 ft. apart perform a double shift to minimize down time.

Shiftable conveyors handling overburden are generally provided with Garland type idlers. These idlers have knuckle joints between the rolls as opposed to a rigid frame. This flexible idler compensates for minor misalignment frequently experienced with shiftable conveyors and reduces the danger of idler roll damage caused by the impact of large lumps. A quick release clamp is provided that could enable replacement of the idler while the conveyor is operating.

In calculating horsepower requirements in a shiftable conveyor system, it is generally a good practice to increase the calculated friction values by 5% to compensate for conveyor misalignment.

Shiftable conveyor systems frequently employ hydroviscous drives, fluid couplings, or wound-rotor motors. These drives have the advantage of providing a soft start that is good practice particularly on large conveyors where alignment is somewhat questionable. An advantage that the hydroviscous drive has over the fluid coupling for high horsepower applications is that in the running mode, it locks up and does not have slip losses that are common to the fluid coupling.

Wound-rotor motors also provide the same soft start characteristics associated with hydroviscous drives. However, they are not as easily adjustable to field conditions that often dictate shortening or lengthening of conveyors from one section of the mine to another.

One of the larger belt conveyor systems operating in Africa is the open cast workings of the Nchanga copper mine in Zambia. It had the greatest earthmoving capability of any similar belt conveyor system in southern Africa. It features belts running at 800 f.p.m. with the system designed to remove overburden at 3000 t.p.h. The initial lift of the

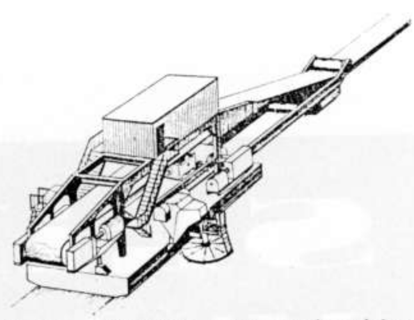

Fig. 6 — Walking conveyor head terminal.

system was 170 ft. and increased progressively by 86 ft. steps up to a total of nearly 1000 ft. as the operating bench levels were lowered. This system was put into operation in 1955. It featured fabric belting, and conveyor acceleration was controlled by scoop-type fluid couplings.

FEATURES OF OVERLAND CONVEYORS

Many types of support structures can be used for the overland conveyors in a mine system.

One type is the wire rope supported conveyor. The conveyor idlers and the belt and load carried are supported by two parallel, nonrunning wire ropes. This results in an inexpensive yet permanent structure that can be easily extended.

Another form of support structure frequently used is tables or benches with premounted, rigid frame idlers. A low capital investment can be achieved for permanently installed conveyors when the idler spacing on the troughing side can be extended to 10 ft. or more and mounted on independent stands founded on augered concrete footings (Fig. 9).

Some installations are in areas of the country where standard conveyor sections as described may be considered a visual pollutant or an attractive nuisance. In cases such as these, a concrete module (Fig. 10) provides a conveyor system support and enclosure that is esthetically appealing and remains competitive for most installations. Although at first glance the cost of the module itself may appear more costly, the equalizer is the savings that accrue from shop assembly of machinery before installation and the ease and speed of erecting 40 to 60-ft. sections.

Long conveyor flights and systems that are regenerative or indi-

Fig. 7 — Head terminal at Nchanga copper mine in Zambia, Central Africa.

vidual flights that have unequal drift times require automatic braking systems. This permits all conveyors to stop in sequence regardless of loading conditions or in the event of power failure. These failsafe braking systems are extremely important on long conveyors where terrain contours produce both positive and regenerative loading conditions. Failsafe braking systems of this type have been installed in numerous installations around the world . . . lending added reliability to the belt conveyor systems. A typical example of a system using a failsafe brake is Lone Star Cement's Davenport, Calif., operation.

Long overland conveyors associated with mines generally have belt speeds in the range of 1000 to 1100 f.p.m. However, speeds up to 1600 f.p.m. have been applied on some systems to date. Because of the extended length and high belt speeds, extra attention must be taken in the calculation of friction values in determining the connected horsepower, as the standard values appearing in most publications no longer apply. Many other factors must also be considered that are generally ignored in standard calculations such as bottom belt cover thickness, idler roll diameter, belt speed, edge distance of the material, or the belt material density and belt sag between idlers, to name just a few, each having an effect on the tension and resulting horsepower requirements.

ADVANTAGES OF V-TYPE RETURN IDLER

Long conveyors, with their inherent high belt tensions, will allow the troughing idlers to be spaced at greater than standard centers. Depending on the belt weight, load carried, and sag conditions, spacing of 10 ft. has successfully been applied. If the V-type return idler is employed rather than the standard flat return idler, other benefits are received without adding to the cost, and in most cases, a savings is appreciated. Because the V-type return affords for a greater load carrying capacity, extended spacing of 20-ft. centers can be used, halving the quantity of standard idlers. This improves the economics and, at the same time, enhances the belt training on the return side of the conveyor.

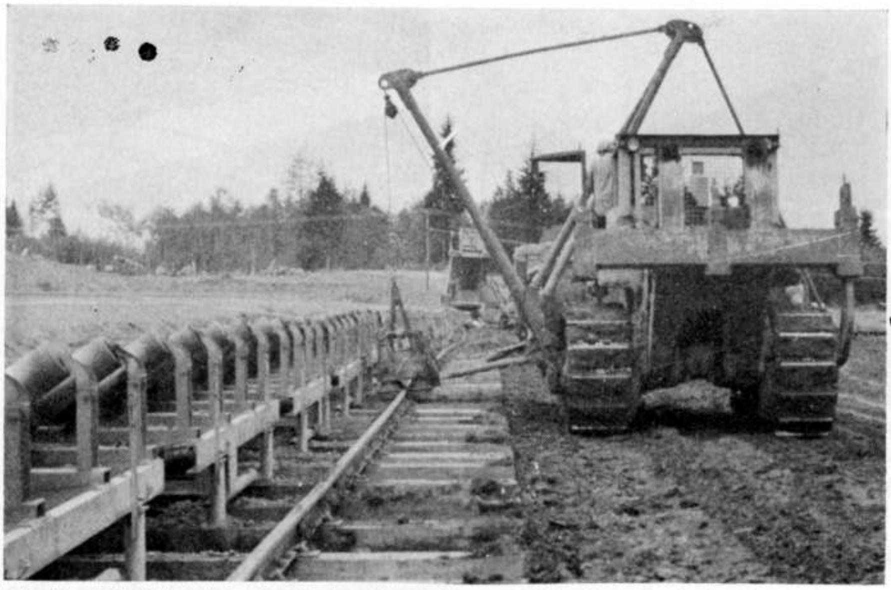

Fig. 8 — Shifting head and pipe layer dozer at Washington Irrigation & Development, Centralia, Wash.

Other features generally employed on long conveyors are belt turnovers (Fig. 11) at both the head and tail ends of the conveyor. Their purpose is to protect the return idlers from material buildup that causes distraining of the conveyor belt and to eliminate costly maintenance of clean up around each return idler. The belt turnover is a device that turns the dirty carrying side of the conveyor belt up on the return run so that the sticky material that clings to the top cover does not come into contact with the supporting return idlers. It is the transfer of the sticky material from the belt cover to the return idler roll that causes wear and a differential in its diameter lending to the distraining of the conveyor belt. Just ahead of the tail end, the belt is again turned as more material is loaded on the conveyor for transport on the carrying side. Because pulleys in the turnover areas are the only ones that come into contact with the dirty side of the belt, clean up of material knocked loose is limited to the turnover areas.

Long conveyors, particularly overland systems over undulating terrain, require a more precise control of the slack-side tension. Rather than using a standard, fixed gravity, counterweight take-up device, either an electric or hydraulic winch (Fig. 12) is employed to provide pretensioning control during start up and lock up for no movement of the take up during deceleration. Deceleration tension control is often necessary to prevent negative tensions that may occur on the carrying side of the belt that can cause material spillage. In general, the use of the automated take up will allow for a more economical selection of conveyor belt and will also protect it from high transient tensions during starting and stopping.

There are a number of conveyors of the long overland variety that have occasional bearing and pulley failures during an aborted start. What causes these failures are transverse vibrations that can produce belt tensions at various points along the conveyor many times the calculated steady state or normal acceleration or deceleration values. Generally, the higher belt tensions and the higher modules of elasticity associated with steel cable belt cause a pronounced transient high belt tension. Transient belt tensions have been found to be the cause of take-up pulleys and the connected counterweights to be pulled past their limits, destroying the supporting conveyor structure and counterweight tower.

Pulley concentricity is another important consideration on high tension belt conveyors. A high tension pulley should be machined true before and after the application of lagging so that it will not produce tension surges or resonant frequencies that can cause devastating results.

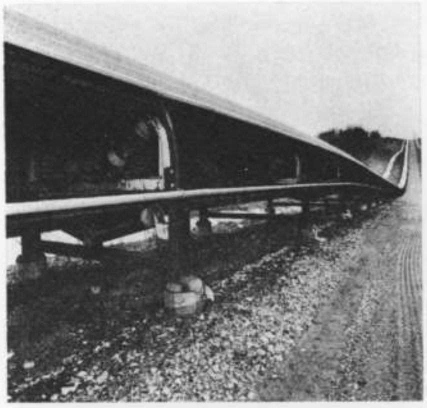

Fig. 9 — Independent idler stand at American Electric Power Co.'s James M. Gavin power plant, Cheshire, Ohio.

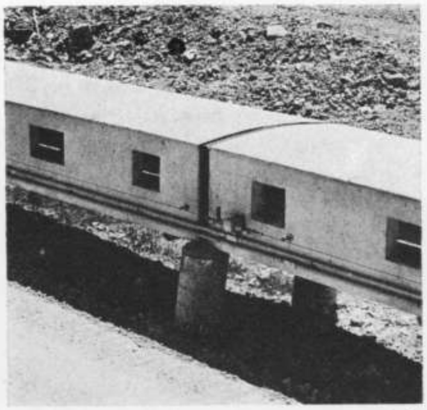

Fig. 10 — Concrete conveyor module at Lone Star Cement, Davenport, Calif.

Fig. 11 — Belt turnover at American Electric Power Co.'s James M. Gavin power plant, Cheshire, Ohio.

BELT CONVEYOR PROTECTION EQUIPMENT

Finally, other system protection equipment should be employed in an effort to help prevent accidental damage to the conveyor belt and related rotating machinery. Belt penetration detection devices are commonly used at the transfer points. Lone Star Cement's Davenport, Calif., plant uses a rip detecting device beneath each transfer point that consists of a counterbalanced tray and relay switch. If a tear begins because a foreign object punctures the belt, the conveyed material will fall onto the tray. The weight of the material on the plate actuates a relay that in turn shuts down the conveyor drive.

The other type of belt protection device senses belt punctures and consists of impact idlers mounted on a movable frame. The entire frame is prevented from moving in the direction of belt travel by a retaining device. If an object punctures the belt and is carried with the belt, it contacts the carriage giving it forward movement causing activation of the stopping device.

Lone Star Cement also employs a high motor torque protection device at each conveyor drive. The device monitors motor current and is tripped, shutting down the conveyor drives, when a preset valve has been exceeded. The tripping point adjusts to match the desired motor torque limit.

Cold weather operation also should be taken into consideration by the conveyor designer as it can have adverse effects on the life of rotating components. Overland conveyors that operate in extremely cold areas are often equipped with auxiliary slow speed drives that keep the conveyor running at a speed between 10 and 50 f.p.m. The cold weather drives serve to keep the rotating components in motion during normal shutdown periods. This prevents hardening of the lubricants making start-up easier. These slow speed drives are also used as an aid to belt inspection, allowing an operator to visually inspect the entire length of the belt as it passes by him.

Long centered conveyors are finding greater use in more and more applications as they prove to be the most economical method of transportation both here in the U. S. and abroad. American Electric Power Co.'s Gavin generating station in Ohio receives its coal directly from the mines. It is a 15-mile long overland system consisting of four conveyor flights, two that are five miles long and two that are two and one-half miles long.

Fig. 12 — Electric winch take up at American Electric Power Co.'s James M. Gavin power plant, Cheshire, Ohio.

The system features water-cooled, eddy current couplings controlling the starting torque of the motors and troughing idlers spaced 10 ft. while the returns are spaced at 20-ft. centers. The idlers are mounted on individual idler stands mounted on augered footings.

This 48-in. wide conveyor travels at 950 f.p.m. and handles 2500 t.p.h. of coal.

The control synchronization of the drives and the relay of electrical signals from the safety equipment is transmitted by a tone control system. A unique pushbutton, coded, radio transmitter is used for emergency shutoff of the conveyor system from any place along the conveyors. This eliminates the need for pullcords for those sections other than the driving and transfer areas (Fig. 13).

CONCLUSIONS

Engineers and operators are finding greater applications for belt

Fig. 13— Coded radio transmitter at American Electric Power Co.'s James M. Gavin power plant, Cheshire, Ohio.

conveyors in strip mines as technology expands and the higher capacity requirements make belt conveyor systems economically feasible. Traditionally, the greatest use of high tonnage conveyors has been in the brown coal industry in Germany. However, in the past 20 years, similar installations have proved themselves successful in the U. S.

With energy costs, fuel rationing, inflation and labor costs as prime considerations, belt conveyors are proving to be economically competitive and have superior availability over other forms of transportation.

Each mine is unique. Therefore, a careful analysis must be made of all modes of transportation to determine the combination of equipment that will be economical, flexible, and throughout the life of the mine, produce the lowest operating and maintenance cost.

REFERENCES

1. Vaka, G. A., and Loeffler, F. J., "Belt Conveyor Drives for Use in the Cement Industry," I.E.E.E., 1977.
2. "Regional Aspects Affect Planning of Surface Mining Operations," Coal Age, Oct. 1976.
3. Hewitt-Robins, "The Conveying System With the Greatest Carrying Capacity in Southern Africa."
4. Robins Engineers & Constructors, "Belt Conveyors," Pit & Quarry, Sept. 1972.
5. Viciana, James J., "Largest Overland Conveyor System," Coal Mining & Processing, Feb. 1975.
6. Schweitzer, F. W., and Dykers, L. G., "Belt Conveyor vs. Truck Haulage: Capital vs. Expense," A.I.M.E., Sept. 1976.
7. Frizzell, Earl M., and Martin, James W., "Cross-Pit Conveyor Systems," Mining Congress Journal, Aug. 1977.
8. Morgan, W. C., and Schermerhorn, J. G., "Stripping With Scrapers and Dozers," Coal Mining & Processing, June 1978.