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OVERVIEW AND CURRENT STATE OF THE ART IN BELT CONVEYING IN SOUTH AFRICA

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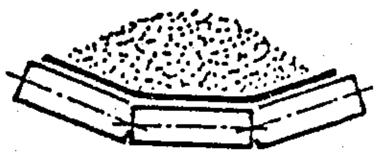

BELT CONVEYORS - DESIGN, OPERATION AND OPTIMIZATION

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BELT CONVEYING IN SOUTH AFRICA

STATE OF THE ART

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C O N T E N T S

S U M M A R Y

A review is given of belt conveyor technology at present applied in South Africa.

The paper illustrates how the latest specifications and design aids can be used to ensure that properly chosen designs are arrived at. A look is taken at mechanical and electrical components in use. Motors, gearboxes and other major items are reviewed. Reference is made to new developments in the field of safety mechanisms and control systems. Refurbishing of belting and "mothballing" of conveyor installation are also discussed.

Sepcial reference is made to Iscor, one of the largest users of conveyor belting in the country. The firm's progress in the field of belt conveyors is discussed, as well as the possible effects of these developments on national and international technology.

1. INTRODUCTION

1.1 Objective

This paper is based on Iscor's experience with belt conveyors gained at its various Works and Mines as well as on data and information which were obtained during contact with other South African mining firms, conveyor equipment suppliers and contractors on numerous occasions.

We will discuss the development and the state of the art in belt conveying in South Africa, as seen from Iscor's viewpoint, especially with reference to COSTS, DESIGN TRENDS and design philosophies.

In conclusion a few Iscor comments will be passed on some technical features including the belt mass, vertical radii, take-ups, transition distances, chutes, belt cleaning, friction coefficients, fault annunciation, belt inclinations, reducers, etc.

1.2 Background

The success of many mining and plant operations is heavily dependent upon the economic (and available) transportation of vast quantities of material, and several factors have contributed to the success of large overland belt conveyors.

Historically rail and truck haulage has been the primary means of ore and waste transportation for the mining industry.

Spiralling fuel costs have further aggravated the situation, and necessitated the evaluation of alternative materials handling techniques.

Belt conveyors offer especially in the mining industry an economical solution for transporting the large quantities of material associated with the high overburden ratios and large tonnages that are prevalent in today's mineral and synthetic fuel operations.

The advantages of belt conveyors have always been well recognised and these include
a high availability factor,
the ability to operate in inclement weather,
low labour requirements for both operation and maintenance,
independence from uncontrolled fuel oil costs, and minimal evironmental impact.

In line with the world-wide trend towards growing international trade in major bulk commodities and increased size in individual shipments, there has been a corresponding requirement for ever larger bulk handling equipment to cope with the need for faster material throughput. This can be seen both at point-of ship loading and power station feed and in the stockyards where the stockpile has almost entirely superseded the bunker.

The need for faster handling rates is apparent everywhere.

Understandably conveyor systems have had to keep pace with the increasing capacities of loading and unloading equipment.

The Iscor Ltd company has pioneered significant advances in mining, utilising inpit crushing and conveying.

Conveying for high capacity systems is typically accomplished by steel cord belts with a design limiting maximum slope of about 30%.

High angle conveyors approaching verticality are now available in larger capacities (pipe conveyors) and, because of their greater flexibility, are used in modern projects.

Normally, overland conveying systems will have several transfer and drive points to accommodate changes in direction, although horizontally curved conveyors are already used in many installations, even in South Africa.

Drive areas are stationary, rotatable or relocatable.

Availability - Experience with conveyor systems on actual installations

Conveyor systems which have been properly designed and in respect of which an effective preventive maintenance program is enforced such as a single shift being allocated each week for scheduled maintenance have paid off in providing availability of up to about 95%.

Studies of actual availability and efficiency experienced with conveyor installations, including shiftable installations which have been in operation for many years, resulted in the following observations.

The main transport stream, i.e. the main loading, including the excavator at the feed end and the plant or stacker at the discharge end, achieved:

- an availability of approximatily 65% based on the total calender time of 365 days per year
- an average efficiency of 55 - 60% of the theoretically maximum feed rate was achieved
- this represents an availability of the individual conveyor belts of over 96% and the availability of the main transport stream is 86%

Other mechanical components have proved to be very reliable, the most important one being the conveyor idler. During a 2 year observation period about 1% of the carrying idlers and 2.3% of the return idlers had to be replaced.

A further significant contribution to increased availability resulted from the introduction of installations with a garland idler instead of the bracket mounted one. This provides

- better belt training
- less shock loading
- fewer stoppages due to idler failure
- simpler transfer point design

In a crusher feed operation a large proportion of the operating interruptions arise due to the presence of boulders, which either choke the crusher or which damage the belt as well as cause difficulties at the transfer points.

2. PAST AND PRESENT ATTITUDES TO COSTS

2.1 Past cost philosophies

In the past, when designing plant, it was normal to give maximum attention to the design of the various processing machines.

The associated conveyors were merely means of moving materials.

However, at an Iscor mining plant, results showed that over 60% of the plant downtime was due to conveyor problems. It was obvious that if these causes were eliminated, production could be increased and work loads on maintenance staff reduced.

In addition, regular plant clean-up times could be reduced as well as the often costly clean-ups necessary after serious conveyor failures.

Because conveyors did not receive their due attention during the design stage, they were generally too narrow, underpowered and generally underdesigned.

Economic studies based on cost figures from current large open-pit mine operations at Iscor and overseas have indicated that maintenance and especially operating costs for large in-pit crushing systems run below R0.24 per ton-kilometer.

Haulage costs for equivalent systems are highly variable and, in a cash flow study by Iscor was as follows:-

COST R MIL.	TRUCKS ONLY	CRUSHING & CONVEYING 30 m.t.a.
Capital	26	33
Operational	86	56
Maintenance	14	9
Total	126	98
Discounted cash flow		26%
Payback period		7 Years

It must be noted that all truck costs are not necessary eliminated of course, and those that remain to operate the system must be included in the evaluation of total system costs.

For systems such as those at Grootegeluk and Foskor mines, the system however uses an excavator to feed into the system directly.

Wherever insufficient capital has been invested in conveyors there will usually be additional annual costs. Iscor records indicate that past savings in conveyor capital costs are squandered in additional running costs within two to three years.

2.2 Current cost philosophies

It is now recognized by Iscor that conveyors must be designed on a "first three year total cost" basis rather than on the initial capital cost.

In this approach the following costs are added to the initial cost:

Operating,
maintenance,
downtime losses
plus the interest on the capital value of warehouse stocks for three years.

Investigations clearly show that long component lives and spillage free operation bring handsome rewards.

For example, it is usually sound economical practice to spend 20% more on the original belt on the understanding that a resulting reduced need for repairs or replacements more than compensates for this additional expense.

There are, of course, occasions when low capital costs are justifiable. This may be the case with temporary or infrequently used conveyors.

There are also special cases where the conveyor has an initially low capital cost. The capital investment cost is then raised later by the use of higher quality or uprated spares.

Whatever the required cost approach, the design approach must be flexible enough to cater for it fully.

2.3 Corrective actions now introduced

Iscor now has at its disposal a set of updated conveyor specifications and a set of related computer programs.

These facilities enable the Corporation to evaluate well designed alternative layouts prior to the tendering stage.

Alternatively, existing conveyors may be upgraded or used in new situations to the best advantage. The specifications and associated computer programs give the user the freedom to select a duty category and capital cost best suited to the given application.

The same facilities enable the Corporation to design or select individual conveyor components of a quality best suited to the required duty. As a result, it is frequently possible to upgrade a conveyor by using replacement components that have longer lives.

Computer aided draughting will be the next step. A decision in this regard have already being taken. A pilot installation is being commissioned at our Vanderbijlpark works.

3. DESIGN TRENDS

3.1 Drawbacks associated with lowest plant tenders

By lowest tender is meant the selection and purchasing arrangement often followed by large organisations.

All acceptable plant tenders are arranged in cost order and the lowest one is selected.

The problem then revolves around what is "acceptable". If the minimum acceptable standard is not properly defined, then the purchaser may frequently accept a low cost tender for a conveyor that may perform poorly in service.

The only counter against the dangers of lowest tenders is the full and proper definition of the minimum acceptable standard-this philosophy is followed by Iscor.

3.2 Examples of previously underdesigned equipment

The Iscor organisation purchases hundreds of replacement conveyor pulleys annually, for example.

If the operating conditions and minimum design standards had been known, the majority of these pulley replacements would not be necessary.

Investigations have shown that 60% of the pulley failures were due to shaft and bearing design shortcomings.

The same comments apply to idler shaft and bearing deficiencies.

Many spillage problems are due to belts that are too narrow, poor chutes, inadequate stringer centres and wrongly calculated vertical radii.

Excessive spillage leads to premature belt, idler and pulley failure as well as high clean-up costs.

Iscor has experienced several cases where take-up towers have not been strong enough to carry the counterweight necessary to prevent belt slip during start-up.

Dozens of conveyors have been provided with motors which practical experience has shown to be not powerful enough. With these drives, component failures occurred frequently.

One infamous inclined conveyor at one of the Iscor Mining Plants was provided with a belt which was so narrow that no belt available at that time was strong enough for the required duty. In addition, the pulley diameters were too small and the angle at the loading point too steep. After the frequent belt failures, the heavy load and belt would be found piled up at the bottom of the inclined shaft. The clean-up process alone took a whole shift in most instances.

The latest know how and design facilities now in use whould have prevented this major problem area.

3.3 Methods now used to ensure high standards

Over a number of years, Iscor has studied many conveyor system designs and analysed its own plant performance. Selection of the 'best' design and equipment for a particular conveyor system has become a major problem, particularly with the trend in the mining industry to even larger, more heavily loaded conveyors.

To overcome this problem, Iscor has as is the case of many other companies, developed computer programs that analyse the given data and give optimised selection of conveyor belt components. This has, in part, been possible due to a more thorough understanding of forces which occur in a belt conveyor system and their effects under certain conditions. These programs enable the designer to establish fairly accurately the design of a long overland conveyor by rapidly analysing the complex variables such as unit loads, stresses, etc and provide answers necessary for a rational choice of components involved in the complete installation.

The biggest hazard for any conveyor is at the transfer point. For this reason designers have to give special attention to the chute layout and ensure that it is perfect as far as possible.

With weaknesses in features such as rock boxes and Langlaagte openings minimised, these chutes now operate very successfully.

It is of primary inportance to ascertain or predict the required operating conditions for the given application.

For example, there must be no confusion between the average and peak tons per hour. A conveyor with six loading points has a more onerous duty than a single loading point.

The Iscor specifications received their major test during the design and tender adjudication stages of the Sishen in-pit crushing and conveying system.

The overall system performance is now being evaluated. Indications are that the desired design performance can be a achieved with ease, and would be cost effective.

3.4 Methods of recording improvement ideas

One special advantage of specifications needs to be mentioned. They form a means of recording any worthwhile ideas that arise at centres where the specifications are used.

Where a user has experienced a certain problem, he can check whether the current specification adequately prevents such problems in future.

4. DESIGN PHILOSOPHIES

4.1 Current Iscor design philosophies

Fundamental to the Iscor design philosophy is the so-called "design capacity". This design capacity is based on the annual tons carried by the conveyor divided by the number of the working hours per annum.

Analyses of the daily performances at Iscor plants show that, during every month, there are often periods of about 3 consecutive days when production is significantly higher than the monthly average. The conveyors in such plants must be capable of safely handling this 3-day peak.

Allowances must be made for periodical production surges and future production increases.

TABLE 4.1.1:

LOW DESIGN CAPACITY RESULTING FROM UNDERESTIMATED DESIGN FACTORS

	Factor	Nominal Value	Actual Value
(A)	No of Tons Carried Per Annum:		
	Average Annual Capacity (AAC)	1 000 000 t/a	1 000 000 t/a
	Load Fluctuation Factor (K)	1,25	1,331
	Design Value for Annual Capacity (DAC)(*)	1 250 000 t/a	1 331 000 t/a
(B)	No of working Hours per Annum:		Ø
	No of Working Hours per Day (Hd)	24 h/d	20,4 h/d
	No of Working Days per Week (Dw)	6 d/w	5,6 d/w
	No of Working Weeks per Annum (Wa)	52 w/a	51,4 w/a
	No of Working Hours per Annum (HA)(**)	7 488 h/a	5 872 h/a
(C)	Design Capacity (DC) in t/h:		
	(DC) = (DAC)/(Ha)	166,9 t/h	226,7 t/h
	(DC) relative to "Nominal Value"	100%	136%

(*) ... Where (DAC) = Kx(AAC)
(**) ... Where (Ha) = (Hd).(Dw).(Wa)

(Ø) ... These values include allowances for downtimes, shift change-overs, weekly start-ups and shut downs, statutory holidays, etc.

The table shows that, for the given conveyor, the design capacity can easily be underestimated by 36% by using factors which appear to be accurate enough but do not reflect to the actual conditions.

An additional important design decision is based on cost. The factors considered here are:

1. Quality of maintenance available

2. Working conditions, e.g.: dusty, damp, etc.

3. Amount of capital available, etc.

TABLE 4.1.2:

SELECTION OF COST FACTOR (KB)

CAPITAL COSTS	RUNNING COSTS	APPLICATION WHERE:	(KB)
HIGH	LOW	1. Labour costs are high 2. Adequate availability of competent staff is doubtful ... and/or 3. Materials are in the VERY ABRASIVE or SHARP categories 4. Plant availability is high	1,00
MEDIUM	MEDIUM	1. Competent maintenance teams are well established ... and/or 2. A few conveyors run at speeds slightly above normal, for reasons such as interchangeability of spares with other conveyors	1,10
LOW	HIGH	SPECIAL CASES: 1. Where low capital costs are of utmost importance, e.g. for dam building ... and/or 2. For long overburden or soft ore conveyors 3. For plants with short life spans, eg. pilot plants	1,25

NOTE: The selected value of KB is used to determine the required belt speed.

A table used for selecting the applicable cost factor (KB) is given.

A higher value for KB results in a faster belt speed and, most often, a narrower belt.

TABLE 4.1.3

MAXIMUM BELT VELOCITY (VM)

CONDITION		(VM IN M/S
All Conveyors not described below		10,0
Boom Conveyors for Stackers		3,5
Trippers with own Travel Motors		3,5
Conveyors upstream and downstream of Primary Crushers		3,0
Trippers with belt-driven Travels		2,5
Conveyors with Discharge Plows on Carry Side		2,5
Conveyors carrying fine and dusty Materials, eg ash, pulverized coal, cement, flue dust, etc		2,0
Conveyors carrying materials which may not be degraded, eg. coke, coal, etc.		1,5
Feeder Conveyors under Storage Bins		1,0
Picking Conveyors	With easy-to-sort Materials	1,0
	With difficult-to-sort Materials	0,5

Note:

The above values are mentioned in the current specification Iscor has installed overland conveyors with speeds of as high as 6 m/s. Others have a speed of 4 m/s.

The long term performance may lead to revisions of the above.

This table shows the maximum permissible belt velocities.

The maximum values are determined by practical rather than economical considerations and are fairly conservative.

The overall Iscor design philosophy has been incorporated in the latest specifications and computer programs.

Even aspects such as increased conveyor clearances for human safety and belt cleaning are defined in these documents.

4.2 Other current design philosophies

It may be of interest at this stage to describe some interesting design trends used by other organisations.

CEMA uses a complex method of calculating conveyor friction. While certain U.S. companies, organisations in the UK, Germany and Iscor use a simpler method involving characteristic values.

Few organisations emphasise the difference between peak tons/hour and annual average tons/hour. This fact alone has been the cause of many underdesigned conveyors and heavy financial losses.

4.3 Comments on various design philosophies

Comparisons have been made of the results of different calculations for the general layouts and main parameters of conveyors using various US, UK, German and Iscor approaches. If reasonable conditions and constants are assumed in each case, the end results are much the same.

Except for the adverse effects of "cheapest tenders" already referred to, the main reason for bad designs in the past has been the assumption of incorrect operating conditions rather than incorrect formulae.

A glaring example of such unwise asumptions has been the use of high drive pulley friction factors during the design of the conveyors for one of Iscor's mining plants. On a Monday, after a rainy weekend, plant start-ups were often made almost impossible because of the slipping belts of many conveyors.

Although Iscor specifies rubber lagged pulleys, it requires the use of 0,28 as the drive pulley coefficient of friction.

This allows proper conveyor operation even under adverse conditions e.g. loss of rubber lagging or the presence of moist clay spillage.

5. COMMENTS ON TECHNICAL FEATURES

5.1 Comments on General layouts

(a) Belt capacity factors

As previously mentioned, it is essential that the so-called design capacity be properly estimated before final designs are made or existing conveyors modified. Excellent designs based on underestimated design capacities will eventually result in unsatisfactory performances.

(b) Coefficient of friction at drive pulley

The coefficient of friction between the drive pulley and belt is an important area where underestimations can easily occur. Such error can seriously affect the overall conveyor design.

REFER TO GRAPH A - Appendix I

Graph A shows that, for the given conveyor, the belt force at the take-up increases by 40% if the coefficient friction is reduced from 0,35 to 0,28.

Special ceramic lagging used on a conveyor at our Newcastle works is claimed to have a factor of 0.7.

(c) Friction Factor for Conveyor:

TABLE 5.1.1

CONVEYOR FRICTION FACTOR (C)

APPLICATION			FRICTION FACTOR (C)
WORKING CONDITIONS	EQUIPMENT ALIGNMENT	MAINTENANCE STANDARDS	
Very clean	Accurate eg. immediately after commissioning	Very high	0,020
Fairly clean	Good eg. conveyor on robust structures	Good	0,025
Rather dirty	Questionable eg. conveyors on woste dumps	Moderate	0,030

Table 5.1.1 shows the values of Conveyor Friction Factor recommended for various working and maintenance standards.

REFER TO GRAPH B - Appendix II

The graph shows that if the friction factor is raised from 0,02 to 0,03 the maximum belt force is raised by 29%.

This illustrates the importance of correctly estimating the relevant friction factor.

(d) Sticky and Moist Materials:

It is essential that the designer makes full allowance for any sticky and/or moist material.

Such materials can affect the following design areas:

Belt speed, belt inclination, material spillage, coefficients of friction and/or belt cleaning.

(e) Chute layouts

Iscor has taken all the aspects of the conventional chute and ensured that they are perfected as far as possible.

With weaknesses in features such as rock boxes and Langlaagte openings minimized, such chutes now operate very successfully.

However, for successful chute designs, it is essential that adequate chute widths are made available through the selection of belt widths that are sufficiently wide.

In this regard, Iscor now ensures that the maximum lump size is not underestimated.

Chutes were recently provided with impact plates. These plates and even the whole chute are made adjustable to suit a range of material conditions from, say, dry heavy rock to moist clay. Overseas roller type screens, some with trochoid disc to maintain forward feed of the oversized material, have been developed and are used especially in rock fill applications.

(f) Belt inclinations

Here, again, Iscor has found that a conservative approach pays dividends.

It is now expected that the maximum belt inclination and the inclination in the loading area will be kept to limits clearly stated in the Iscor specification.

This approach has increased the belt load carrying capacity while reducing spillage and the associated wear and damage problems.

(g) Take-up layouts

Iscor is generally satisfied with gravity take-ups for permanent installations. The gravity take-up is still the most commonly used and preferred in this country. It is the most reliable one if properly designed. Where space or mobility is a consideration, the winch type is adopted. However, on long-centred conveyors an automatic take-up is always incorporated to provide the correct drive characteristics and to absorb tension variations due to belt elongation on the start-up and braking mode. Where this type has proven to be inadequate, the problems have usually been due to:

1. Underestimated belt forces

2. Underestimated take-up distances ... and

3. Poor protection against spillage.

Where screw take-ups are used, the following rules are applied:

1. Allow for belt forces which are higher than those for gravity or motor-driven take-ups ... and

2. Use steelcord belting, where possible, in order to keep the take-up distances suitably short.

In recent times, Iscor has acquired experience with motor-driven winches. This variety of take-up appears to have promising features specially on long and high speed conveyors e.g. they can be programmed for start-up as well as normal running conditions.

However, it is advisable to provide the winch with a "jog button" in both directions and to make the tensioning 'manual', and while leaving the strain gauge 'on' permanently. An instrument near the winch will indicate the load, as well as the low and high tension status.

(h) Vertical radii

It is essential that concave radii be correctly calculated. This will prevent belt lift-off during start-up, normal running or slow down. Such a fault may lead to excessive belt training and spillage problems.

In the case of convex curves, not only the belt radii but also the idler spacings must be correctly estimated.

In those formulae where empty conditions are applicable, the mass of belt used shall correspond to fully worn covers and the minimum radius should be big enough so that belt edges do not buckle and the tension in the centre of the belt does not exceed the allowable belt tension.

(i) Transition distances

Many formula and approaches are used to reduce the maldistribution of edge tension to within safe limits and to prevent buckling of the centre portion of belt.

Before the correct transition distances are calculated, the conveyor designer must select the most appropriate idler height relative to the terminal pulley top height.

For example, it is our opinion that, where possible, the top of the tail pulley should be in line with the bottom of the loading idler troughs. This ensures a proper forming of the belt in the loading area. Generally it is found that this is neglected in practice, resulting in spillage problems at the loading points.

5.2 COMMENTS ON COMPONENTS

Stoppages of conveyor belt systems due to component failure even for short periods can represent a costly loss, especially for high capacity bulk loading installations.

It is therefore essential that the highest quality equipment is selected.

(a) <u>Belt Carcass</u> (for more detail the paper presented by Mr Davies at Beltcon I still applies)

We know that belt is the most expensive component in a belt conveyor system. The main consideration of design would therefor be to keep the capacity outlay low initialy, but to ensure that useful life is not reduced by other conveyor components. It is therefore desirable to reduce belt width by running the conveyor at a speed limited only by the nature of the load and not the idlers, for instance.

Iscor uses synthetic carcass and steelcord belts almost exclusively.

For strategic reasons, Iscor requires that, where possible, conveyors generally be suitable for either synthetic or steelcord belts. This will permit maximum belt interchangeability during a crisis involving shortages. Such design versatility is often surprizingly easy.

Experience has shown that it is not wise to use a belt carcass strength near the maximum available. It is usually far better to simply use a wide belt and/or faster belt speed. The above is especially true where relatively small diameter pulleys have to be used and thick belt carcasses are not suitable.

REFER TO GRAPH C - APPENDIX III

The graph being displayed shows that for the given conveyor, a 86 % increase in belt speed reduces the belt force by 76 %.

Iscor now attempts to match the top cover, bottom cover and belt carcass lives.

The cover thicknesses must be adequate for the load impact duties and the cutting actions of rocks and pebbles caught between the belts and pulleys.

Due to the low recycle times, short belts should have relatively thick top covers.

(b) Pulleys (also refer to paper presented by Mr Lloyd at Beltcon 1 and Mr King at this meeting, Beltcon 2)

Belt tensions speeds and widths have been increasing on installations in S.A. over the last couple of years. This has forced users in this country also to look very closely at the design approach and Iscor has decided to follow the proven practice used in Europe.

Studies have shown that the fatigue criteria of pulley shells is of extreme importance and can be subjected to up to more than 500 million full stress reversals in an average system life due to dynammic shock loading which could be caused mainly by acceleration and braking.

In this paper, some views on pulley failures have already been given.

Iscor has made significant progress in the following fields:

1. Easy methods of selecting adequately designed pulleys,

2. Pulley welding techniques,

3. Long-life bearings and bearing seals ... and

4. Long-life laggings for a wide range of material conditions.

(c) Motor Drives (Refer also to the Beltcon 1 paper)

The trend even in S.A. toward ever increasing conveyor capacities is reflected in the increase in drive power.

Long single flight conveyor drives of more than 5 km are already in operation in this country and practice has shown that it differs from that of short conveyor lengths only in that system inertia is likely to be higher and acceleration time becomes critical - being longer to avoid overstressing the belt.

A gradual, stepless increase in torque to a value sufficient to get the belt moving, followed by a pause to allow system shocks to dampen, than a more rapid run up to full required torque at full speed would be the ideal start up for a conveyor.

The general rule followed in a design with multiple pulley drives is to use equal power, as standardization of drive components far outweigh the slight advantage of matched or proper power sharing requiring different sized motor drives in the primary and secondary drives.

Typical drive arrangements are used in the materials handling field, with equal power components at or near the head of a discharge point of the conveyor.

However, for long-centred conveyors where belt tensions can be reduced by about 20% using a tail drive is common, especially were additional cost for cabling and electrical controls do not outweigh any advantage gained by belt tension reduction.

The primary choice of motors lies between:

1. Squirrel cage motors with flexible couplings,

2. Squirrel cage motors with fluid couplings,

3. Slip ring motors with flexible couplings .... and

4. D.C. motor with flexible couplings.

There are numerous possibilities for speed control and it would depend on the particular installation in question and the capital available.

(d) Reducers:

It may seem strange at first that Iscor now specifies maximum reducer masses and maximum centre distances.

1. Applicable design capacity,

2. Maximum belt forces,

3. Maximum belt carcass strengths,

4. Minimum belt cover thicknesses,

5. Minimum pulley diameters,

The question of whether or not spare belting is required should thus be answered at the time the original belting is being ordered. This is desirable from a cost standpoint, as the extra length, as a spare piece can be produced along with the regular belting at no extra cost per metre. If, at a later date, another length of belt is required as a spare or on an emergency basis, the cost per meter may be higher, not to mention the delay in production time.

The amount of spare belting required is dependent on the following factors:

1. Importance of conveyor - major or minor
2. Type of service - severe or mild
3. Length - long or short centre to centre
4. Expected belt life - short (5 - 8 years) or long (over 8 years)
5. Type of installation - permanent or temporary.

Careful consideration of the above factors helps determine if

1. complete spares should be purchased
2. partial spares should be purchased
3. no spares be purchased at all

Normal practice is to keep one length of belting of the longest single flight installation for each make and size in stock.

An additional last factor is the amount of successful belt width and carcass strength rationalization carried out by the given centre.

The explanation is simple: Iscor has a preference for the modern compact reducer based on high quality heat treated gear materials such as EN36A case hardened and ground.

With regard to reducer layouts, the first choice is the less expensive parallel shaft reducer. This is so in spite of the relatively more complex baseplate.

Shaft-mounted reducers are becoming very popular. However, special attention, must be given to the finish tolerance, shrink fit element size and especially assembly procedures whenever these are applied.

Noise factor is becoming more important and manufacturers of gearboxes are well advised to give particular attention to this aspect.

(e) Idlers

The proper selection of idlers, with low running resistance to reduce power and belt size and minimise vibration, is seldom given the importance it deserves. Idlers are second after belting in cost in a long system and the primary source of power loss. It is therefore logical for full utilization of capital invested that every idler must be reliable and trouble free, capabable of extended operational periods without attention while not contributing to undue wear, mistreatment of and risk to the belt.

After many trials, Iscor has now settled for type C3/C4, deep grooved single row ball bearing with optimum internal clearances as standard for all idlers.

Idler shaft diameters are now generally larger than before and are of prime inportance, considering that shaft deflection have proved to be the main cause of bearing failure.

Minimum friction labyrinth seals have been developed and appear to be satisfactory.

(c) Refurbishing of belts

One of the major causes of concern for industry is cost and downtime on conveyor systems. We know that, with constant use, conveyor belts become worn, torn and frayed. In the past, the tendency was to replace these belts with new ones. Today the trend in S.A. is towards refurbishing the belts by the user or by a repair company.

European firms claim to have successfully refurbished belts up to 5 times.

Table no 5.3.1 indicates the possible savings to be expected when refurbishing belting.

The belt is first inspected for holes, rips and cover damage. The belt is X-ray scanned, showing its profile on a video monitor and recorded on a tape. Should it be decided to refurbish the belt, the tape is replayed over the video monitor. The tape is calibrated to the belt that has to be refurbished, and the bad spots can thus be plotted on the belt itself.

TABLE NO 5.3.1

TYPICAL COMPARISON BETWEEN REFURBISHING AND NEW BELT PRICES

BELT WIDTH mm	TOP COVER mm	BOTTOM COVER mm	REFURBISHING PRICE R/M	NEW PRICE R/M	% SAVING
750	8	3,2	R65,00	R80,00	18,75
900	8	3,2	R70,00	R95,00	26,31
1 050	8	3,2	R75,00	R110,00	31,81
1 200	8	3,2	R80,00	R125,00	36,00
1 350	8	3,2	R90,00	R185,00	51,35
1 500	8	3,2	R95,00	R210,00	54,76
1 800	8	3,2	R105,00	R355,00	70,42

(d) Belt cleaning

Although there are a number of belt cleaners on the market and in use, belt manufacturers and users are still searching for an effective cleaning method. A paper is also being presented on this conference dealing with this subject.

Where the materials are sticky, belt washing systems are to be used. Many installations at Iscor mine centres are performing satisfactorily.

It is important that belt washing systems include methods of separating the waste and recovering the washing water.

(e) Electrical

For its more complex conveyor systems, Iscor has found it advisable to provide automatic control equipment. This is a trend that is found in most new installations in the country. Logic controllers are replacing conventional relay systems on belt installations and have proved to be much more reliable and compact than relay control systems. However, because of its inherent reliability it puts the spotlight more on the field instruments used on the conveyor system.

(f) Safety and protection systems

Most conventional conveyor installations are normally equipped with instrumentation package including underspeed switch, belt run-off switch, blocked chute detectors, rip detector, emergency trip wire system and metal detector. Some are very efficient and reliable whereas others, such as rip detection, blocked chute and level controls, are not very successful in certain applications.

(g) Conveyor lighting

This is an area which needs more attention on most installations and is usually neglected during commissioning.

Iscor has established that for

<u>low-risk areas</u> along side the conveyor belt a minimum of 5 lux is adequate

<u>high risk areas</u> such as drive stations a minimum of 50 lux could be considered sufficent

<u>crusher, stacker and reclaimer</u> areas, adequately illumination is provided with 20 lux.

OVERHEAD MAGNETS AND SEPARATORS

Overhead magnets, magnetic pulleys and conveyor separators are in wide use. Their effectiveness depends very much on the application and importance attached to them by the operating staff.

Belt Scales

Various types of belt scales are in use currently, namely mechanical, electromechanical and nuclear scales.

Field experience by Iscor indicates that nuclear type scales do not have any advantage over other scales and are more costly. There are many disatvantages such as legal requirements that must be met.

Communication

Any one or more of the following systems are used effectively:

radio,
telephone or
an 'intercom' communication system.

It was found that personnel adapt very quickly to public adress type intercom system, although an initial resistance to such a system is normally experienced.

The intercom system is especially suitable for a quick exchange of information along the conveyor belt. It also enables the control centre to contact a number of places simultaneously.

With a portable radio-transceiver a person can always deny a call especially when the radio is turned on soft and the person called is alone. An 'intercom' equipped with loudhailers attracts the attention of everybody in the vicinity and response is normally found to be immediate.

Moth-balling a Conveyor installation

This practice is becoming prevalent in our times even in South Africa. The following procedures are recommended and followed by industry.

A conveyor system taken out of commission for mothballing would be for short (up to six months), medium (6 months to 2 years) or long (longer than 2 years) term.

Short term

The best and cheapest way of short term "mothballing" is to leave the conveyor as it is on site. The oil in the gearboxes should be checked to find out whether there is water present. If water is present, the oil should be changed.

Medium term

Gearboxes

The shaft should be turned weekly. This is to ensure that wear, as a result of gear point contact, does not occur. Due to the turning, electrolytic action is also prevented. The oil should not be drained but, before going back into service the oil should be replaced.

Preservation oil is available to replace the oil in the gearboxes before storage. This oil also assists in protecting the gears above the oil level.

Conveyor belts

Conveyor belts are attacked by two agents: the sun and ozone. The black of the belt absorbs the sun's heat and gives rise to a higher temperature in the belt. However, this can be prevented by either covering the belt by using a canvas, or white-washing the belt. Belts are inherently protected against ozone, being manufactured from syntetic rubbers. If more protection is needed silicone oil or anti-ozone paint is used on the belt.

Motors

Motors must be covered for protection against dust and vibration.

The motor shafts must be turned once a month to prevent damage to the bearings.

After the mothballing period the motors must be serviced as before at start-up.

Long term

Where a conveyor system is to be taken out of commission for longer than two years it would be wise but very expensive (this could be prohibitive) to dismantle the whole system. It could then be stored properly in a shed or used somewhere else.

Pulleys and Idlers

They must also be turned weekly to another point of rest because the weight that rests on the idlers causes permanent indentations in the bearing race after some time.

Local idler manufacturers are offering balanced idlers which are especially important in high speed conveyors to eliminate a possible tendency towards vibrating the structure.

Iscor has recently installed a number of conveyors with garland idlers. The results seem to be satisfactory at this stage.

However, initial indications are that return garland idlers of the disc type should not be used on steep inclines. With these, excessive disc rubber wear has been noticed.

5.3 Comments on auxiliary features

(a) Services associated with conveyors

For Iscor, conveyor structures especially for shiftable and overland conveyors, are now designed to support the pipes and cables necessary for the following:

1. Drinking water,

2. Compressed air (within plant areas),

3. Electrical power ... and

4. Lights

More attention is now being paid to portable belt repair workshops suitable for belt splicing as well as cover and edge repairs.

(b) On-site belt storage

An evaluation of past results indicates that the need for spare belting can be reduced to a minimum if the following are properly predicted and used in the overall conveyor design:

5.4 Care and maintenance

A well equipped maintenance workshop with the appropriate personnel has been shown to be essential for the proper operation of a conveyor belt system in order to achieve high availability and efficiency.

In such plants, when operating on 3 shift basis, a daily 2-hour maintenance stop is considered necessary when belt scrapers, pulleys, gearboxes, belting and electricals are serviced. Regular weekly 1 - 2 shift planned maintenance stops are often introduced to enable execution of large repairs and scheduled maintenance work. An experienced, well disciplined crew is required.

Continous supervision of and attention to transfer points are becoming more expensive by the day - necessitating relative high number of operating personnel. The trend is thus towards full automation with the necessary supervisory equipment, monitoring and controls being utilised.

6. Future

Many psychological as well as technical barriers to very long flights and high belt speed have to be overcome, especially as far as materials handling in open pits are concerned. Overseas countries, for instance Germany use already, 6 m wide belts and speed of up to 10 m/s successfully.

Maximum power for a single head motor drive drum has increased from 3 000 KW to 10 000 KW for an installation equippped with a type 7100 belt for a lift of 1 000 m.

As the result of the world wide success of belt-conveyor systems, especially the shiftable type, efforts will also be made to utilise the so far proven technical and economical advantages of conveyor transport for other branches of mining operations, right up to the face of the mine. This has already been implemented on Iscor open pit mines (Grootegeluk and Sishen) for waste material handling, thus replacing diesel driven trucks.

The latest phase of developement indicates an increasing willingness of solid-rock/ore mining branches to test and introduce continious conveyor-belt transportation in combination with mobile crushing plant, to replace trucks entirely.

7. CONCLUSION

In conclusion, it must be stressed that the state of the art of belt conveying in South Africa has now developed to the stage where full recognition of the specialized nature of the subject is given and where design technology now demands complex and painstacking investigation of every component, if satisfactory performance is to be maintained.

The combination of good design philosophies and high standard specifications used in the design of conveyors can only help to realise full optimisation and achieve the best advantage for the belt conveyor user through the extensive use of experienced conveyor consultants and proven computer programmes.

Finally, as already indicated we are sure that there are too many users of conveyor installations designed with a view to capital costs first whereas they should rather have opted for a better system with lower annual/operational costs.

8. ACKNOWLEDGEMENT

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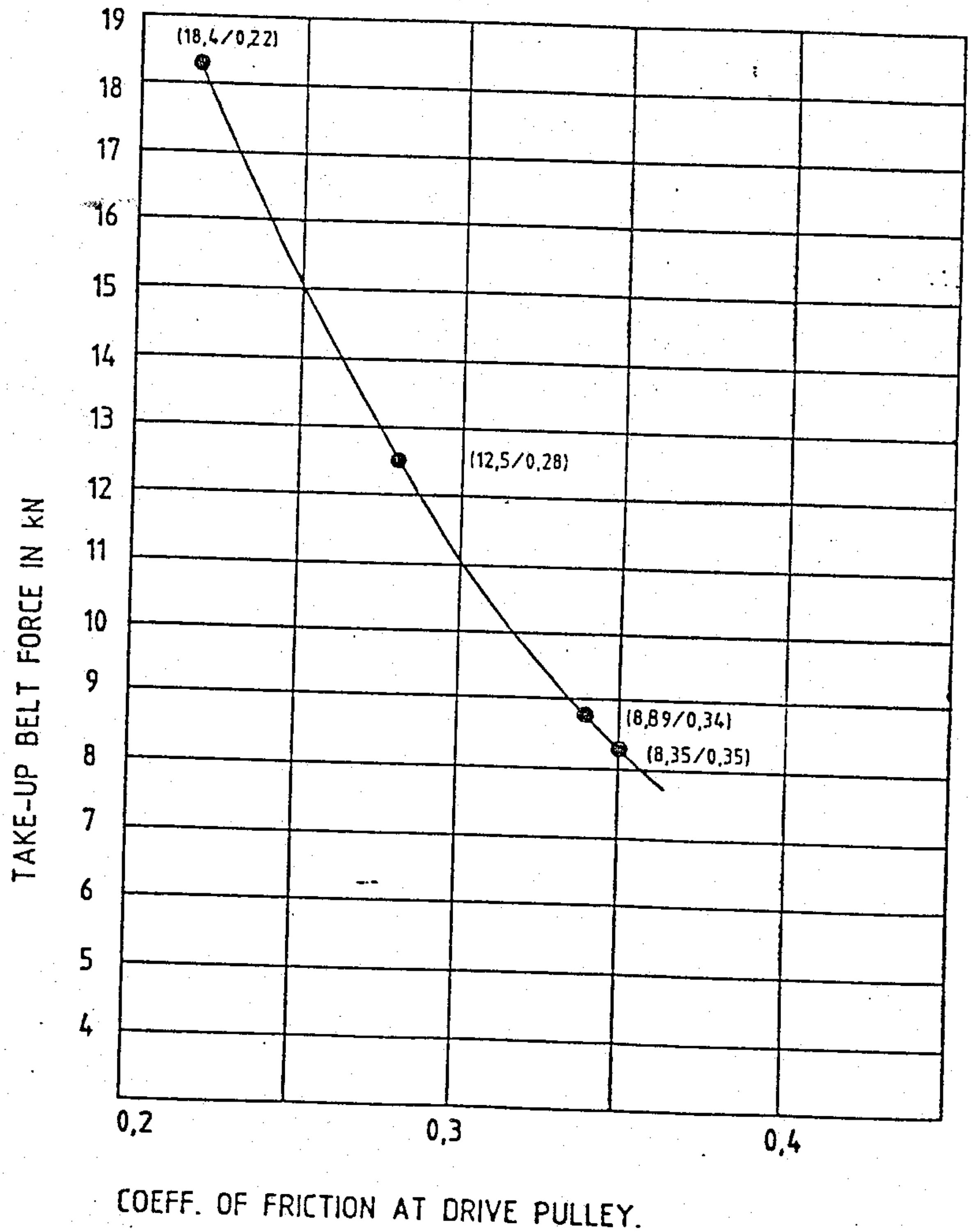
GRAPH A

TAKE-UP BELT FORCE - DRIVE PULLEY FRICTION.

EXAMPLE:

LENGTH = 400m LIFT = 2m DESIGN CAPACITY = 1200t/h
TAKE-UP NEAR HEAD PULLEY BULK DENSITY = 1,5t/m³



GRAPH B.

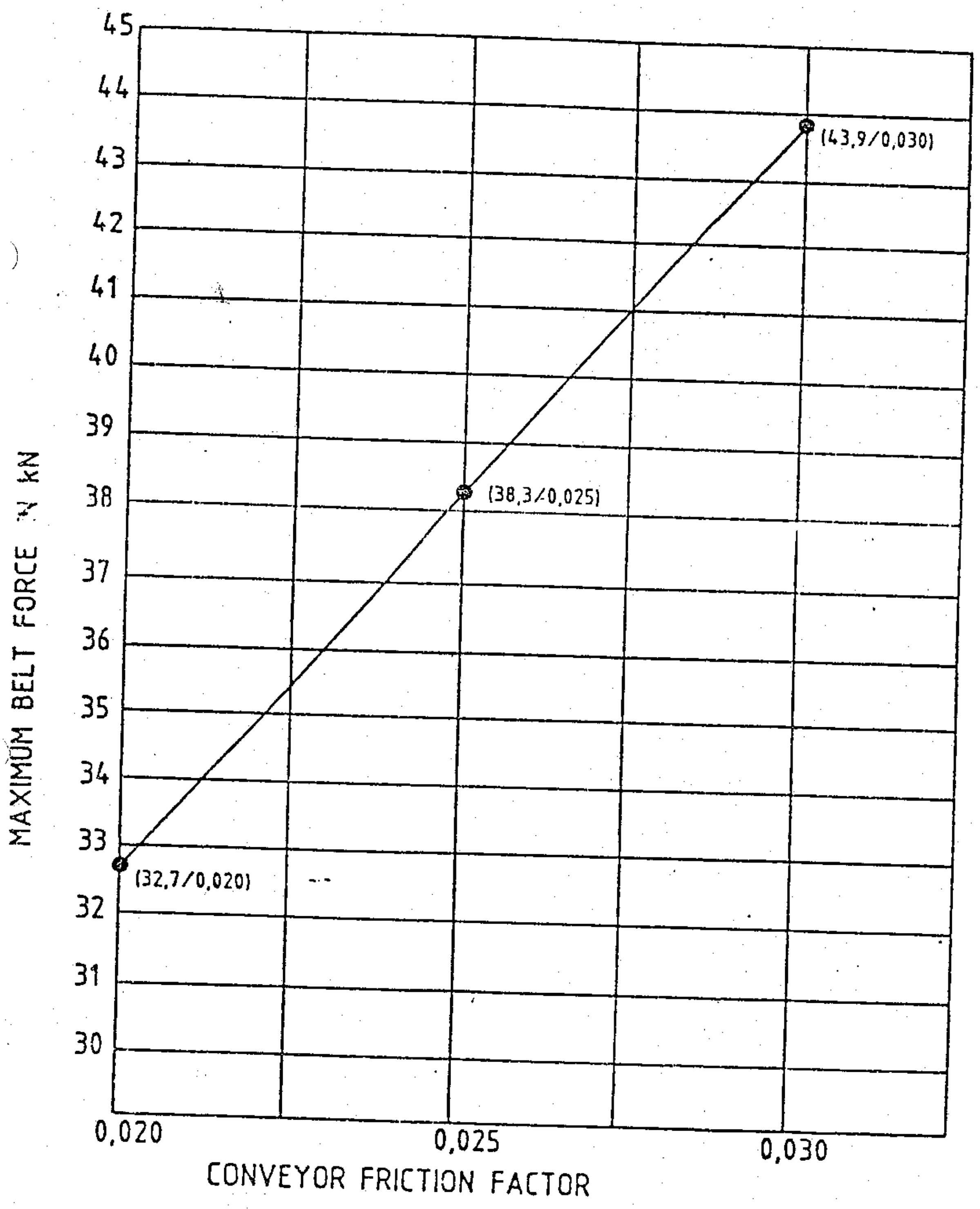
MAXIMUM BELT FORCE - CONVEYOR FRICTION FACTOR.

EXAMPLE:

LENGTH = 400m
TAKE-UP NEAR HEAD PULLEY

LIFT = 2m

DESIGN CAPACITY = 1200t/h
BULK DENSITY = 1,5t/m^3

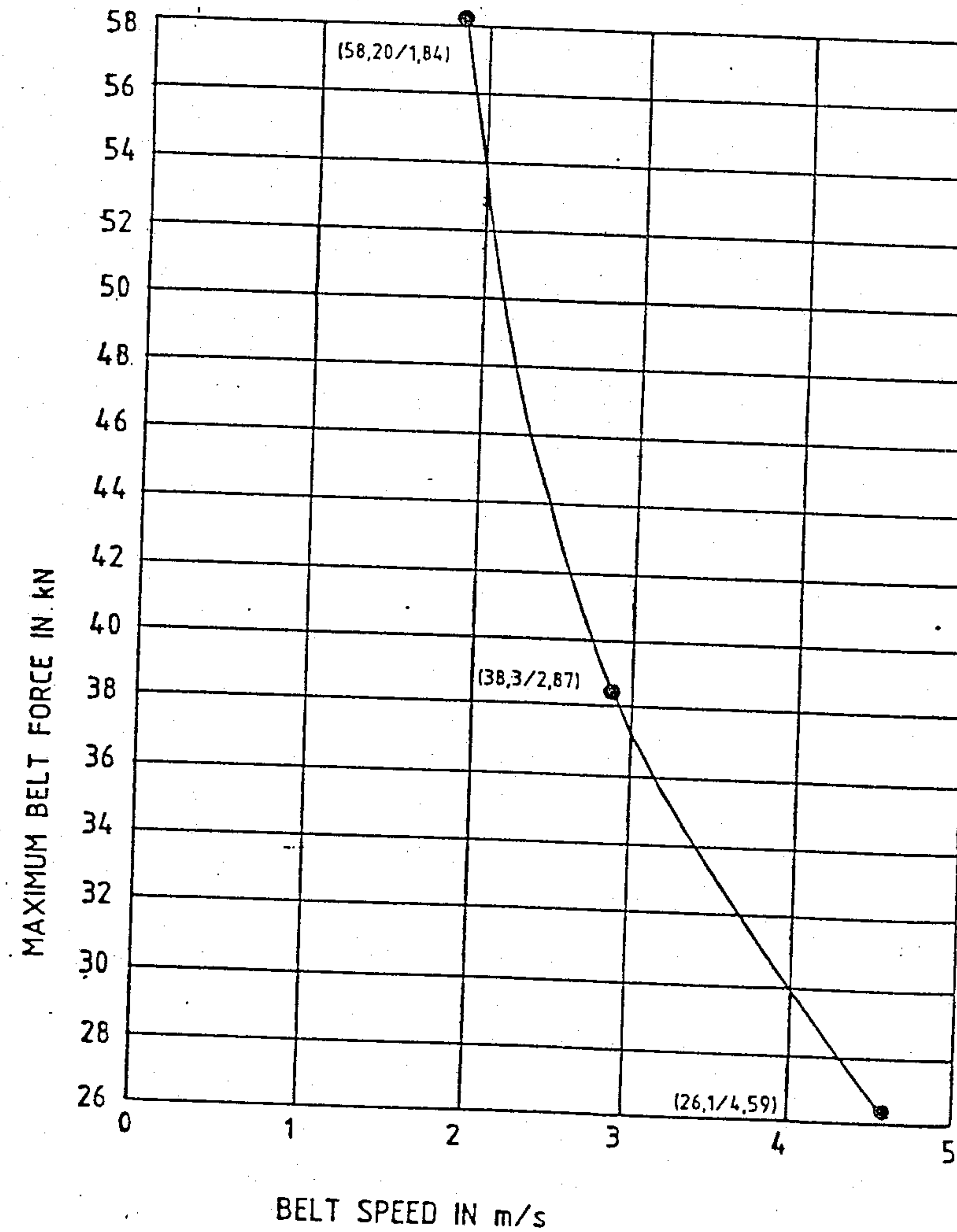


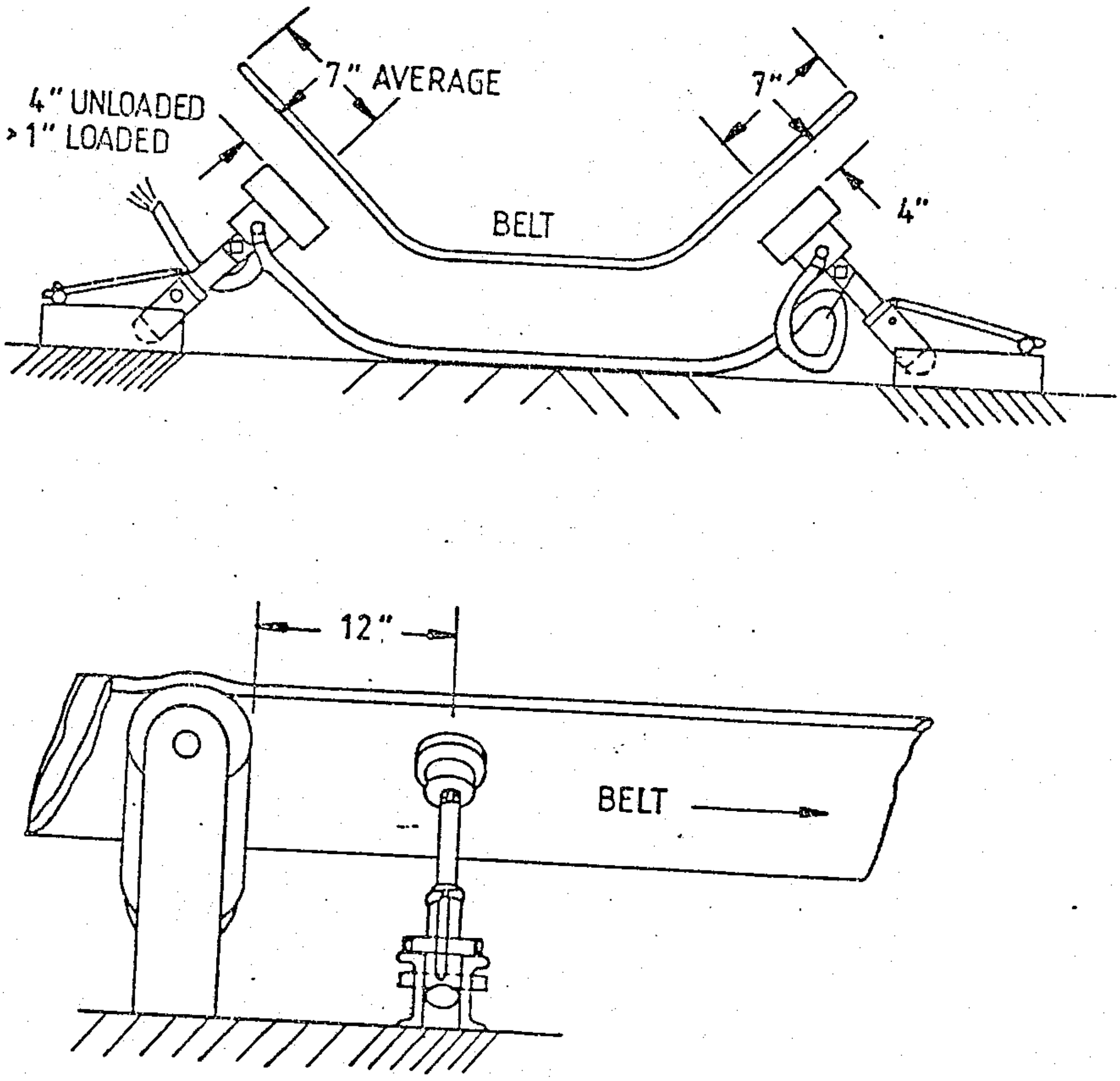
GRAPH C

MAXIMUM BELT FORCE - BELT SPEED.

EXAMPLE:

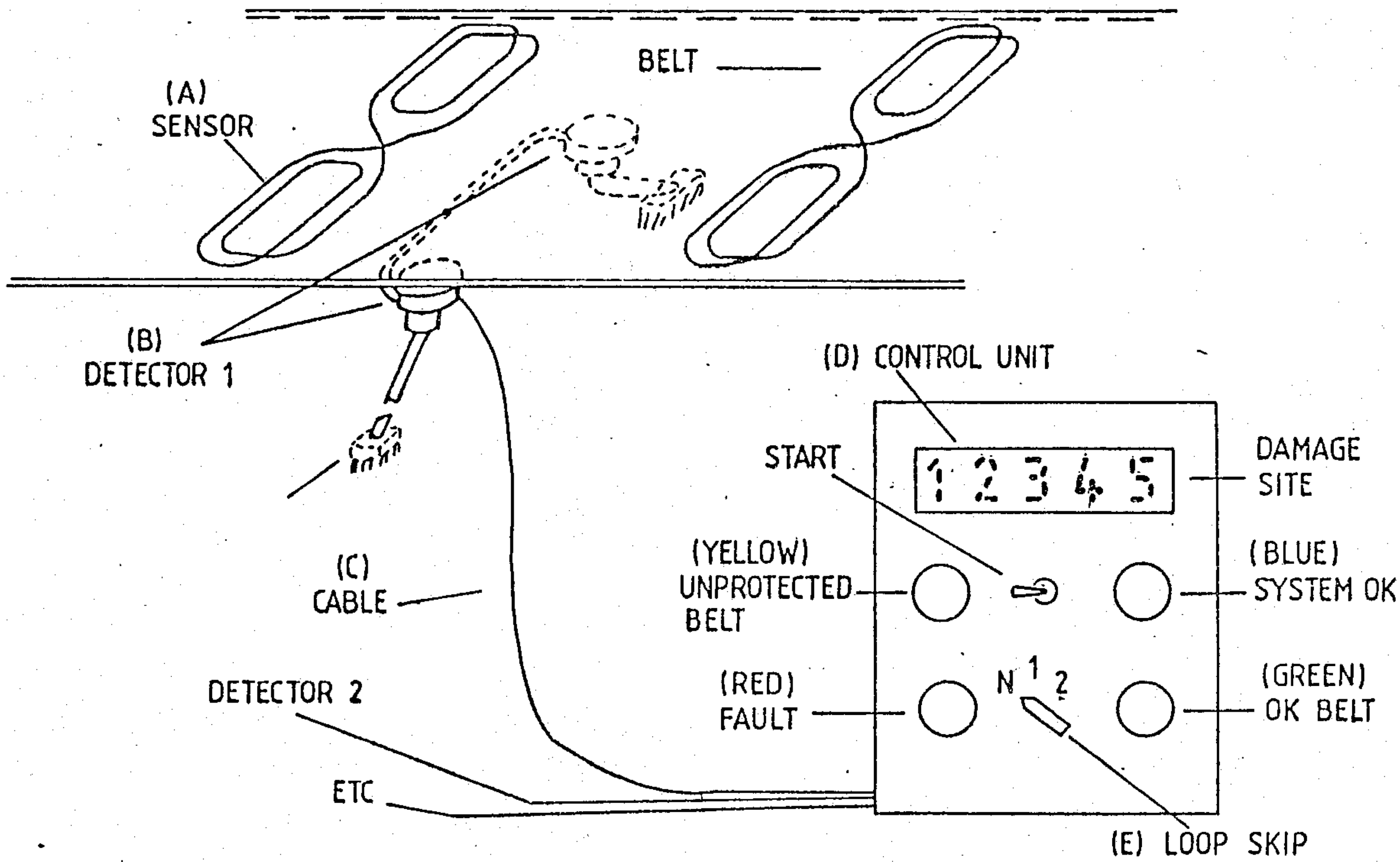
LENGTH = 400m LIFT = 2m DESIGN CAPACITY = 1200t/h
TAKE-UP NEAR HEAD PULLEY BULK DENSITY = 1,5t/m³

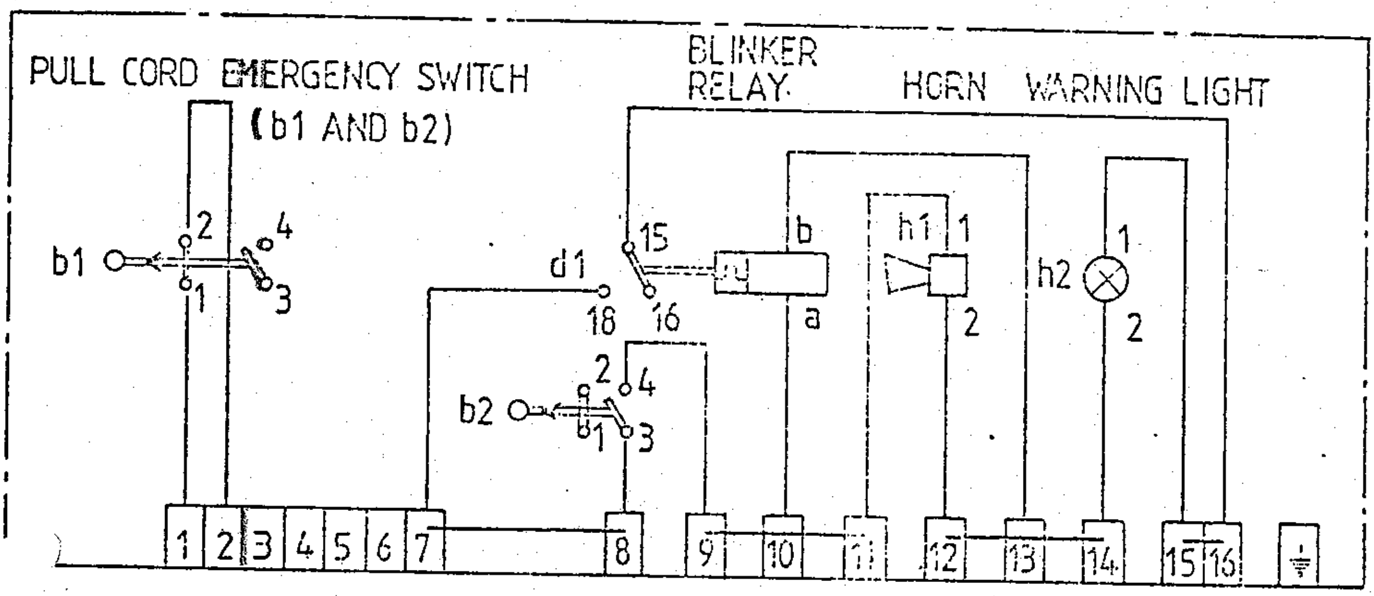


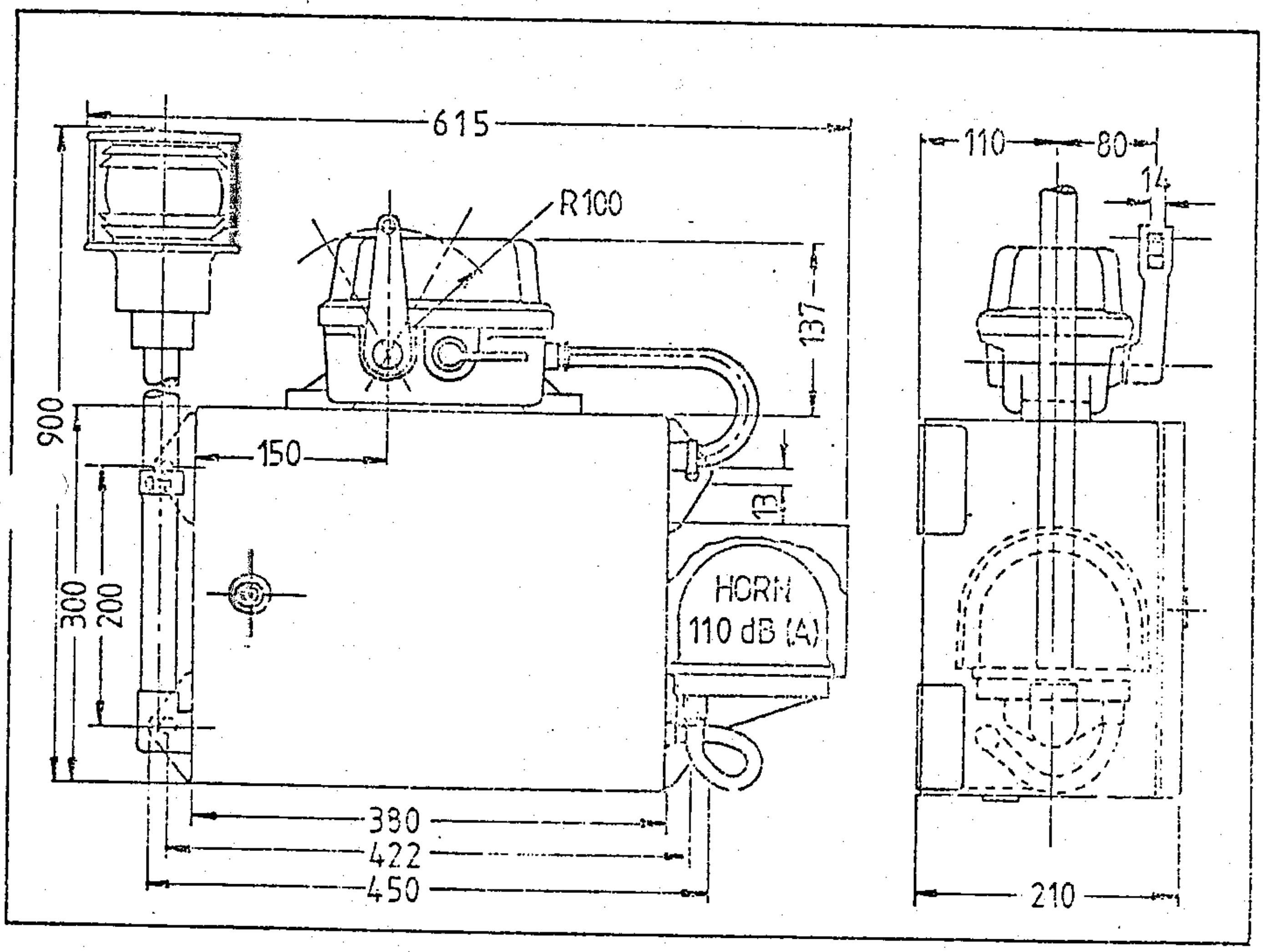


RIP DETECTOR INSTALATION

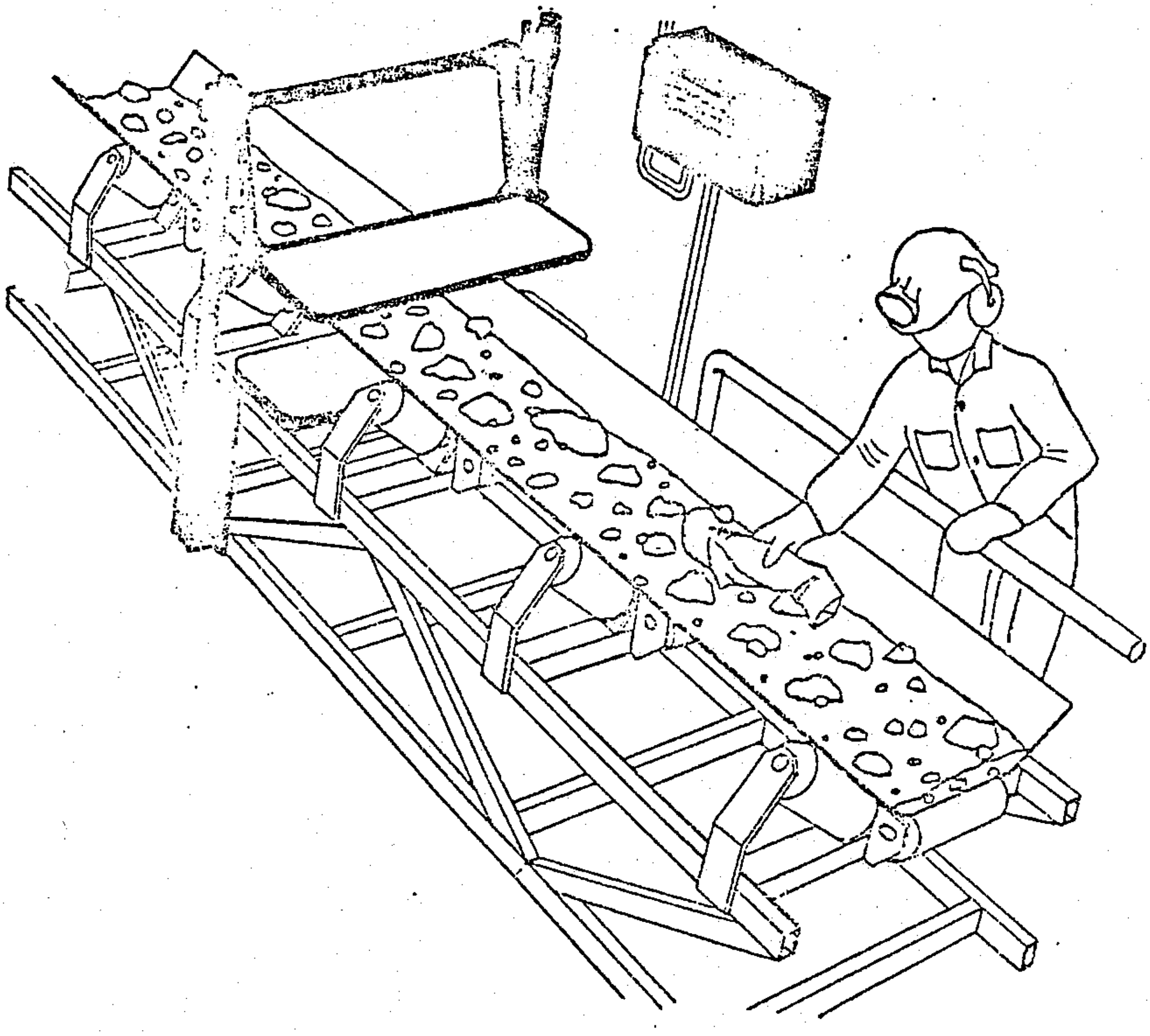
SYSTEM DIAGRAM



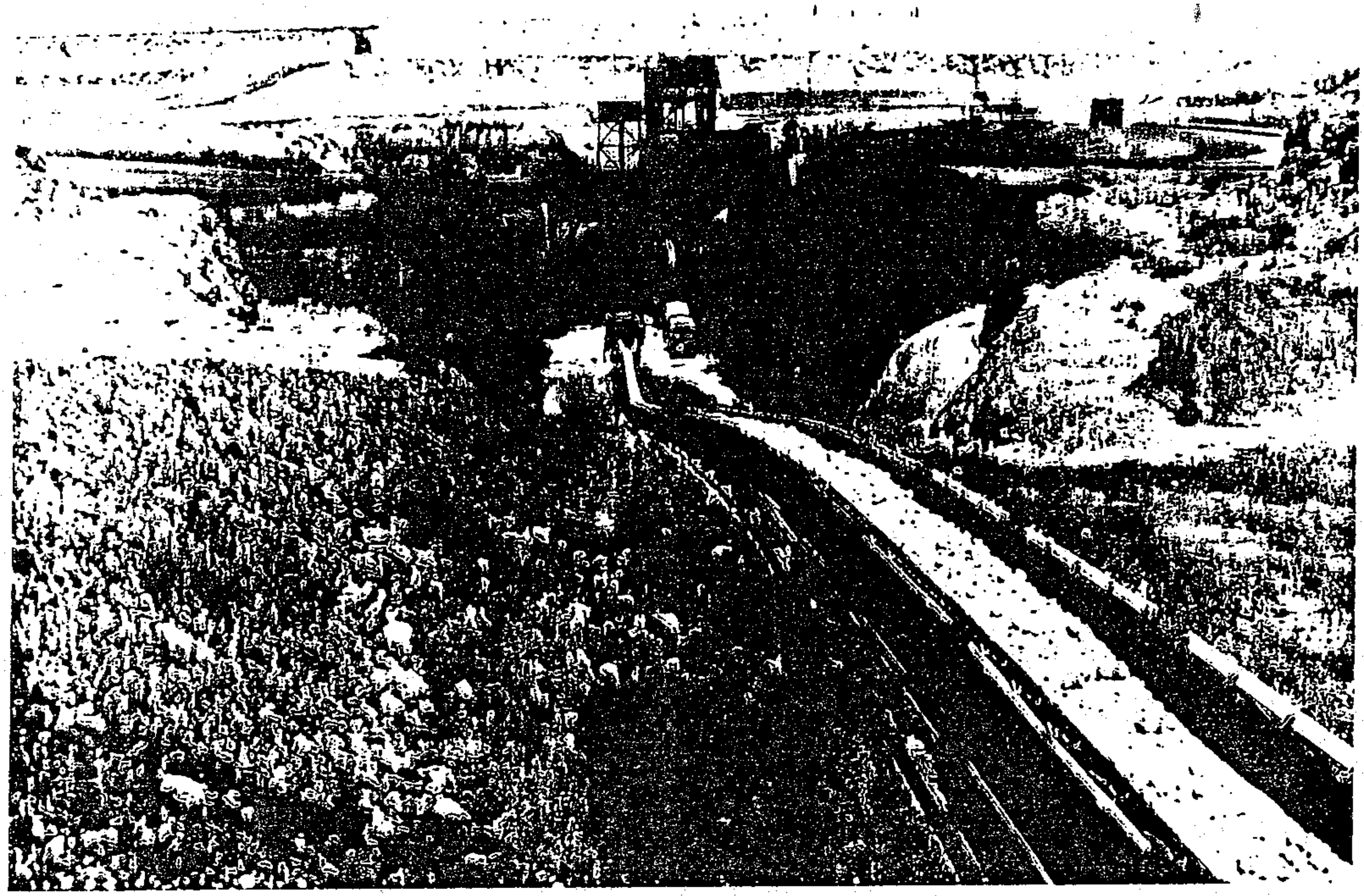




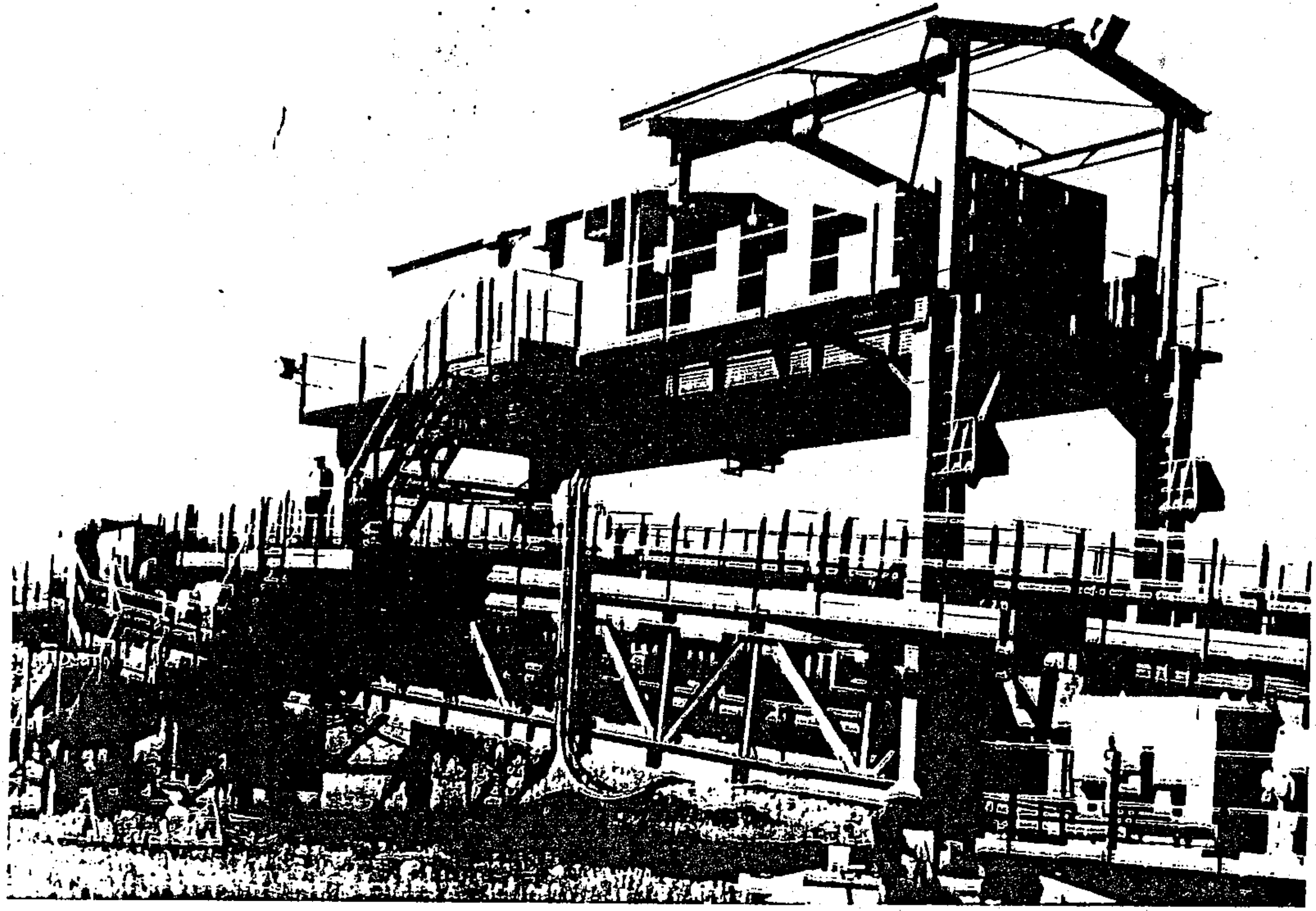
EMERGENCY TRIP WIRE SYSTEM



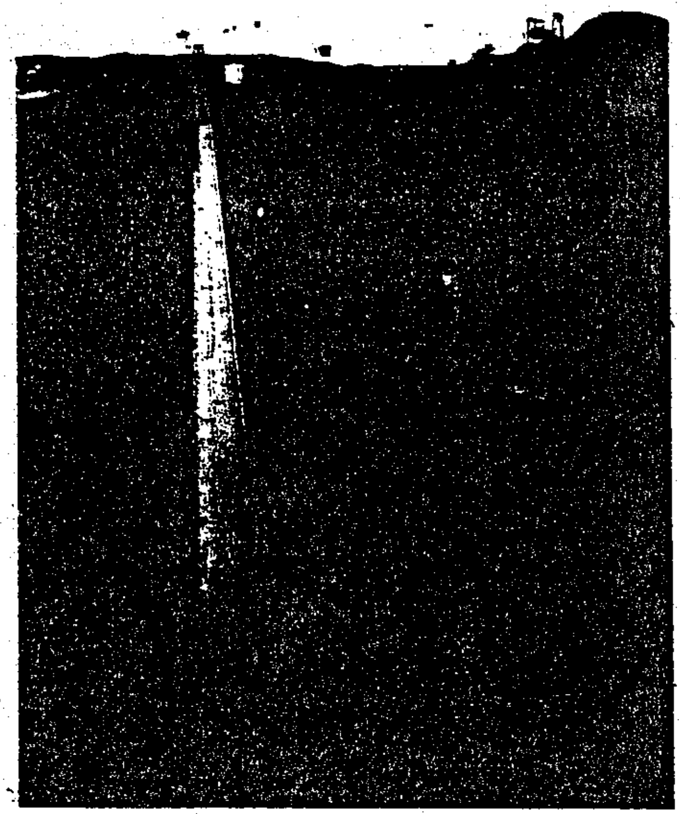
METAL DETECTOR



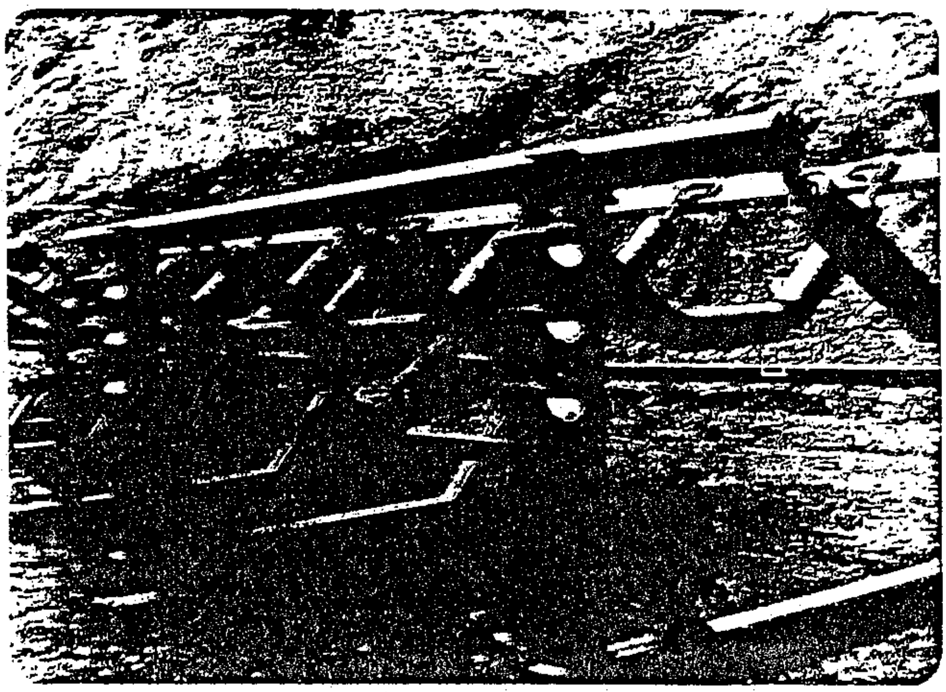
In-pit crushing system with its removable belt conveyor. This is the biggest semi-mobile in-pit crushing system in South Africa.



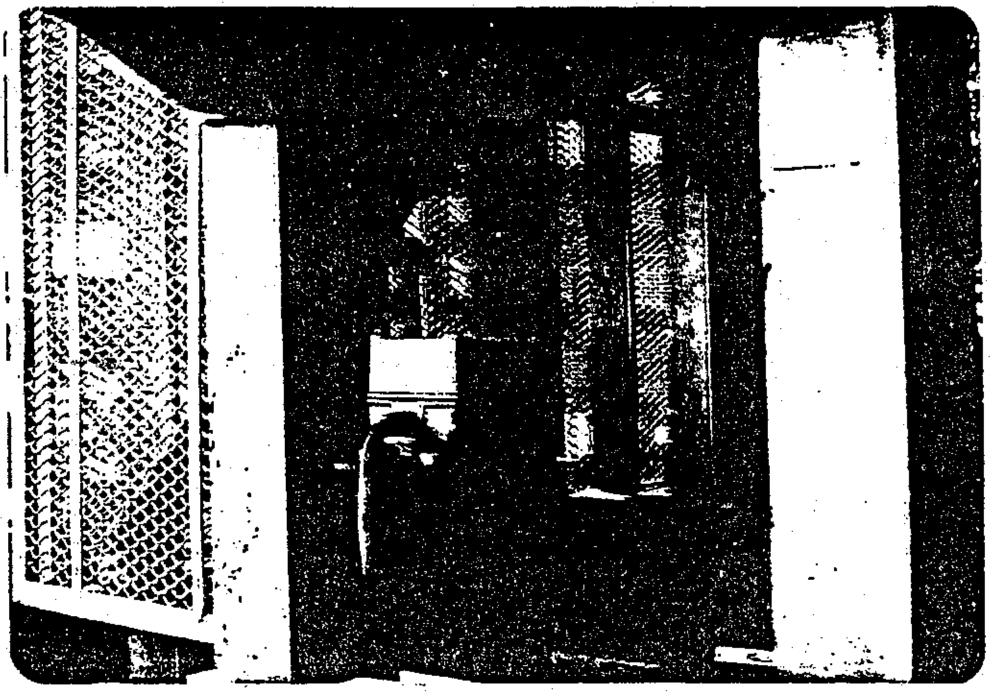
A typical moveable head station for a big conveyor. There are three drives of 500kW each.



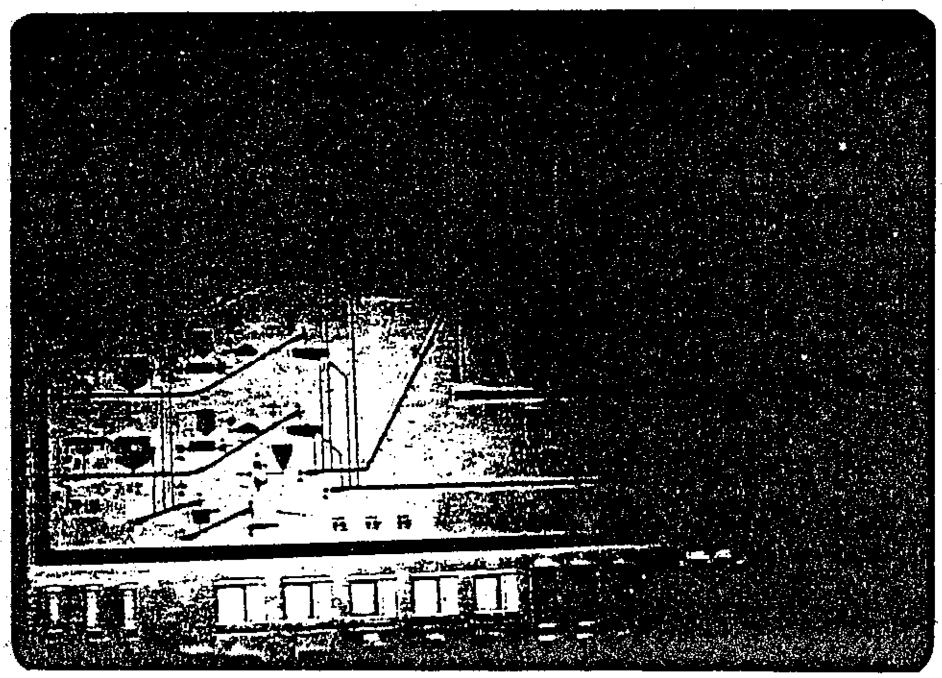
An example of a high speed conveyor (5.6 m/s) 1200mm wide belt.



Shiftable conveyor module with garland idlers.



The trip wire and cut-out switch of a primative but effective rip detector. The material drops through the rip in the belt onto the trip wire and loose belt pieces hook to stop the system.



A typical control room with display panel and control console showing also a conveyor system.