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TITLE: DEVELOPMENTS IN ASH CONVEYING

Escom now has four major power stations at which ash is conveyed to the disposal site by belt conveyors. The various systems are designed to handle from 1 100 to 2 060 ton/hr of moist coarse and fly ash in cake form. The plants in question have now been running for up to 2 years and the dry ash stacking system at Tutuka and Lethabo is already well established.

The broad principles on which the ash is produced, and disposed of, are outlined, and several of the problem areas discussed.

Specific design aspects dealt with are, redundancy, layout configuration, transfer points, chute linings, moving heads, belt speeds, trough angles, surcharge angles, loading, idlers, idler lagging, system specification, control and instrumentation, and corrosion protection.

An indication is given of future trends in Escom's usage of ash conveyors.

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## 1. THE BACKGROUND TO ESCOM'S ASH CONVEYOR BELT SYSTEMS

The purpose of this paper is to present to designers, operators and contractors both the rationale behind the system choice, and the parameters for the detailed design. This experience has been gathered over 7 years of the design and application of belt conveyors to the handling of large tonnages of ash.

The concept of conveyor transport in ash is not new to Escom. Up to forty years ago this was common practise on chain grate boilers. With the advent of pulverised fuel boilers the slurry system was widely installed.

Then in 1979 Escom initiated a review of power station ash handling designs. As a result 5 power stations are being built with belt conveyor ash systems. Of these, 3 are already running fairly successfully. They are being commissioned at 15 month intervals (Tutuka 1984, Lethabo 1985, Matimba 1987, Kendal 1988, Majuba 1991). The use of conveyor belts for ash transport was followed 2 years later by the dry cooling system at Matimba. This further supported the move to dry ashing, as there is less effluent water to be disposed of on a dry cooled power station, and the wet slurry system provided a convenient more but more expensive outlet which is no longer required.

The move towards the use of conveyor belts for transport of moist ash on a continuous basis was due to recurring operational problems with the slurry system. The batch basis, as installed before 1980, was adversely affecting availability of boilers and precipitators.

The major ash related material handling innovations introduced were:

1.1 Continuous extraction of ash from the boiler and precipitator hoppers.

1.2 Ash transport to the disposal area in a moist condition by twin overland conveyor belts.

1.3 Disposal of the moist ash on surface dumps or in open-cast pits using stackers and spreaders.

1.4 Boilers designed to use low to very low grade coal of 16 and possibly 14 mJ/Kg Calorific Value. This leads to large quantities of ash of 16 000 to 20 000 tons/day which required reliable, cost effective disposal.

It is the last-named feature that really has set the scene for Escom's move to dry ash handling plant. The decision to use belt conveyors for overland transport and ash stacking was made taking into account power and water consumption, capital cost, maintenance costs, environment, feasibility and sites available. The complex picture presented by all these factors was analysed in depth. This resulted in the decision to use a belt conveyor system. This decision has just recently been repeated at Majuba, the fifth of the new generation power stations. However, it must not be taken for granted that a wet slurry system will never be installed again at Escom. Each station is evaluated on very site specific factors, with the co-operation of Operating, Civil and Environmental Departments.

## 2. A DESCRIPTION OF A MODERN ESCOM POWER STATION

In order to understand the background to the Escom ash problems and solutions, it is necessary to give a very brief outline of a new power station, its operation and layout. See Figure I of a typical modern Escom power station layout.

Each power station has six boilers of ± 650 Megawatt capacity, in a line at 85 m centres. The ± 120 dry tons/hour/boiler of ash that is produced is split into 2 fractions, namely:

80% ie 96 dry tons/hr of fly ash of -0,2 mm size, and

20% ie 24 dry tons/hr of coarse ash normally -100mm size although the coarse ash lump size can be up to 2m x 1m x 0,5 m in size, and bigger on rare occasions.

The fly ash is swept up through the boiler with the furnace gas and is collected in nearby electrostatic precipitators. It is passed from there in the dry state by pneumatic or mechanical means into adjacent 12 hour storage/surge bunkers. Beneath these bunkers are large conditioners (humidifiers or unloaders). These produce a "dry slump" cake of 18 to 20% moisture content.

The coarse ash product falls out the bottom of the boiler at a very erratic rate into a water bath of ± 1,5 m depth. This has a slow moving submerged drag link chain which conveys the ash up a slope to dewater it for belt transport.

Both the above two processes feed their product to a common belt between the two systems, namely the boiler and the precipitator. This mixed ash is then conveyed to a disposal site via as few transfer points as possible. It is then stacked by 35 m boom stacker to 50 m height in two steps and later covered with soil and grass for return to agricultural use within 2 years of placement.

The above picture must be seen in the light of large sudden changes in ash production rates, particle size distribution (especially on coarse ash) and quality of coal and hence ash. The mode of boiler operation will also have a big influence on the ash produced.

In this highly uncertain design environment the decision was made to use a transport medium that is relatively insensitive to load, to nature of the product and normally requires a lower level of operator training while at the same time is the cheapest solution on a life-cycle cost basis.

## 3. DESIGN CONSIDERATIONS

The overall principles of ash plant design are listed below with more general comments in Section 4.

## 3.1 Ash Belt Systems

Ash belt systems should be designed with 100% standby, ie duplicated or twinned to cater for the continuous boiler operation. One boiler at Matla Power Station has now run for 300 days continuously. This would have allowed no outage for maintenance on a single belt system.

This requirement applies to the main system; but if an alternative system such as a clinker bin at the boiler is available to receive coarse ash then a single belt can be accepted. This will also eliminate the highly undesirable stoppages of the coarse ash system in the event of the main belt tripping.

## 3.2 Transfer Points

Transfer points of twin belts should enable either belt to feed either of the following two belts. Ideally, this should be by means of a moving head which feeds the ash directly onto the following belt minimising height difference and no high angle impact with a chute. A maximum 20° impact angle is advisable to ensure no hang-ups in the chute. An adjustable impact plate in the chute provides considerable flexibility as it allows one to vary the above angle. Very generous chute proportions are advisable.

Figure II shows one of the moving head systems that have been found successful by Escom on ash systems. It shows that the carriage (cross hatched) is capable of moving to deliver onto either of the two following belts up to 30 m apart. The carriage is moved backwards or forwards either by a rack and pinnion or by a winch and rope system with limit switches. The latter is favoured as it minimises the effects of spillage. Various systems exist to support the idlers when the head is in the forward/extended position but the scissors action shown works well. The best alternative to this problem is a shuttle belt which produces a further belt to be cleaned amongst its other problems.

3.3 Chute Linings

Chute linings of 25 mm thick tiles of zirconium aluminium ceramic have proved successful although the running time to date is still too short to predict the life accurately. Radiused chute corners of 400 mm curvature will prevent hang-ups. The effect of impact of coarse ash lumps is almost neglibile as it is largely cushioned by the fly ash. Chromium carbide linings were initially used but were found to be too rough even at $65^{o}$ chute angle.

3.4 Troughing Angle

A troughing angle of $45^{o}$ on idlers to prevent wet ash spillage is advisable. A surcharge angle of $0^{o}$ should be used, as the initial profile of the ash on loading soon flattens out, especially on long belts.

3.5 Belt Speeds

Belt speeds are limited to 3,5 m/sec and thick belt covers are not seen as vital. 8 mm top and 6 mm bottom cover is seen as sufficient to give an estimated life of 7 years, on long belts with a high cycle time. The effect of temperature is not serious and normal belting can be used throughout as the ash is all quenched.

3.6 Idlers

Idlers should be of robust design to minimise replacement, ie 4,5 mm shell thickness. Rubber lined idlers are not recommended due to increased power consumption and vibration caused by eccentricity of the rubber lagging. Polyurethane idlers are under test with promising results thus far.

## 3.7 Inclination of Ash Belts

The maximum recommended inclination of an ash belt is 12°. Inclinations of 14° and 16° exist, but the run back of poorly dewatered coarse ash is a problem.

## 3.8 Belt Invert Level

A carrying belt invert level of 1,2 m above the walkway gives a good compromise between access for cleaning, and convenience of operation.

## 3.9 Return Belt Ploughs

Return belt ploughs are favoured to protect the belt pulleys.

## 3.10 Belt Scrapers

Belt scrapers are a key item, and should be of the staggered multi-bladed overlapping type with ceramic tips and flexible plastic sheets to shed scrapings. Scrapers should be duplicated, ie a primary scraper on the pulley followed by one other as far back as possible. Polyurethane scrapers were originally installed with a very short life. A large amount of development work and better performance is being achieved.

## 3.11 Belt Washing

Belt washing is not generally favoured unless wash water can simply be dumped locally, eg on the dump. This is due to problems of slurry pumping in small lines over long distances.

## 3.12 Instrumentation of the System

The instrumentation of the system is very important. Belt motion, motor current, alignment, belt rip, fluid coupling, chute blockage and pulley failure should be monitored.

3.13 Dual Drives

Dual drives and automatic belt tension systems for start up are interesting developments which enable belt classes to be reduced. They appear to work well. The use of delayed fill and scoop couplings is widely accepted resulting in soft starts for the conveyors. This is particularly true for larger belts over 1.0 km long.

3.15 Each of the belts should be operated alternately for 60% of the time to ensure availability of the standby belt.

3.16 Belt Operation

As far as possible each belt of the twinned pair should be used in conjunction with its successive belt, ie the A route should normally be used throughout as should the B route. This will simplify the immediate change-over to the other route in the event of a trip. Remote operation of moving heads is not favoured, but is possible. It is advisable to test the moving head weekly to ensure it is in working order.

3.17 Computerised Design Package

A computerised design package has been evolved for conveyors, pulleys and idlers to check tenderer's designs; but detailed design of conveyors by Escom, for supply and erect contracts is not envisaged. The clear acceptance of full design responsibility, in all respects, by the contractor, is essential.

3.18 Alkalinity of Ash

The high alkalinity of the ash spillage, especially when saturated, will lead to pH values of 10 to 12. This will have a corrosive effect on the Zinc in the galvanised coating on any steel components. This factor together with inconvenience of site repairs, favours the use of a red lead primer and rubberised paint topcoat.

### 3.19 Security Considerations

Security considerations together with ease of construction have resulted in the widespread use of bolted 6 m conveyor modules on all overland belts on ground level. It is felt that a sabotage attempt on a module could be repaired within a few hours and would cause very localised damage and call for a few dismantled modules being held in the store.

## 4. DISCUSSION

### 4.1 Basic Design

Each of the ash conveyor systems designed to date has twin belt routes to ensure a maximum cost effective availability and good maintenance. A R3 billion plant should not be put at risk by an inadequate R30 million ash conveyor system, ie 1% of total cost.

For this reason, each belt line is capable of removing all the ash produced, and eliminating a 12 hour backlog in 24 hours with the station running at 100% load, using the worst quality of coal anticipated. The other line is then available for maintenance or emergency use. It is possible, but unnecessary, to run both belt lines simultaneously.

The true nature of boiler ash is difficult to predict. The moisture retention, density, adhesion, abrasiveness and formation characteristics are so variable that one must design for worst conditions. For example, conditioned ash density can vary from 700 to 1200 $t/m^3$. This invariably turns out to be justified.

## 4.2 Emergency Dumping of Ash

It has been found advisable to position the first transfer point inside the security area. This enables one to position an emergency dump area with 24 to 36 hours storage of ash at the end of this belt. This can easily be done if the following belt is at an angle to the first. A third position of the moving head enables one to simply overshoot the first two positions and dump the ash on the ground for dozing away. It can then be picked up and dumped onto one of the belts by front-end loader when the overland system is available again.

## 4.3 Belt Training

The first of the mixed ash belts, known as the transverse belts, have up to eighteen feeding points onto them, with varying tonnage rates and trajectories. This calls for very careful training of the belt as spillage in this area is very disruptive to the station's operation. For this reason a slow speed and a wide belt is installed.

## 4.4 Interface

As can be seen from Figure 1, the immediate area around the boiler and precipitator is very congested. It is therefore difficult to introduce such a major item as a conveyor belt. Routes must be planned, and frozen well in advance, with the requisite power supply and access facilities allowed for.

## 4.5 Disposal of Effluent Water

One of the influencing factors in ash handling by conveyor belts is the disposal of effluent water. This means that the moisture content of the conditioned ash is kept as high as possible, consistent with good conveyor practice, life and belt scraper performance. At 25% water content, (ie 25% water to 75% ash) an easily handleable cake results, but at 26% it is a sloppy sludge. As a result it is important to monitor the conditioning process carefully aiming at say 20% moisture. This will reduce maintenance costs considerably. Well conditioned fly ash with 20% moisture will leave a belt very clean, even without scrapers. This is not to say scrapers can be dispensed with.

4.6 Position of Ash on Belts

The relative position of fly ash and coarse ash on the belt is important. There is a considerable benefit in placing fly ash on a belt first if possible. This is because coarse ash is very abrasive and difficult to clean off a belt. Such ash is often produced with high moisture content (up to 50%). This can upset the ideal water content referred to above. So the optimum practice is to place the wet coarse ash on top of slightly underwetted fly ash.

## 5. FUTURE TRENDS

5.1 The use of the so-called "pipe conveyor" has proved very successful on coarse ash handling, on Lethabo Power Station where a very tortuous route had to be followed to bring the coarse ash out of the boiler house. See Figure III. The benefits of steeper slopes, curved routes of 60 m radius, and the elimination of spillage from the return belt are much appreciated. The concept is sound and cost effective at Lethabo, but each case should be evaluated on its merits. It is being considered for future applications.

5.2 The production of the damp cake by conditioners is seen as an area calling for further attention. It can lead to sludge or dust, being produced. A system of pelletisation would make for very simple transfer points, but the tonnage through-put of these machines is small in comparison to conditioners.

The emphasis then is on simplicity and reliability with cost effectiveness in the overall power station context.

## 6. CONCLUSION

The overall conclusion that Escom has reached is that all applications must be optimised on their merits, but that the use of belt conveyors is feasible and justifiable, especially when the tonnages are large. The support of environmental considerations join forces with operational advantages to make this option attractive. Each installation is an improvement on its predecessor as the process of careful optimisation is practised stringently.

It must however be remembered that Escom is not in the conveyor development business. We want cost effective designs but they must be well tried and tested. There is no point in building a power station with an unreliable ash plant.

An invitation is extended to contractors to approach Escom's Engineers to discuss and assess their design priorities and concepts. This is very much in accordance with our new open handed attitude to the public in general and contractors in particular.

## 7. ACKNOWLEDGEMENTS

The writer wishes to thank Escom management for permission to present this paper.

Thanks are also due to a number of contractors who have contributed comments and concepts to the material presented.

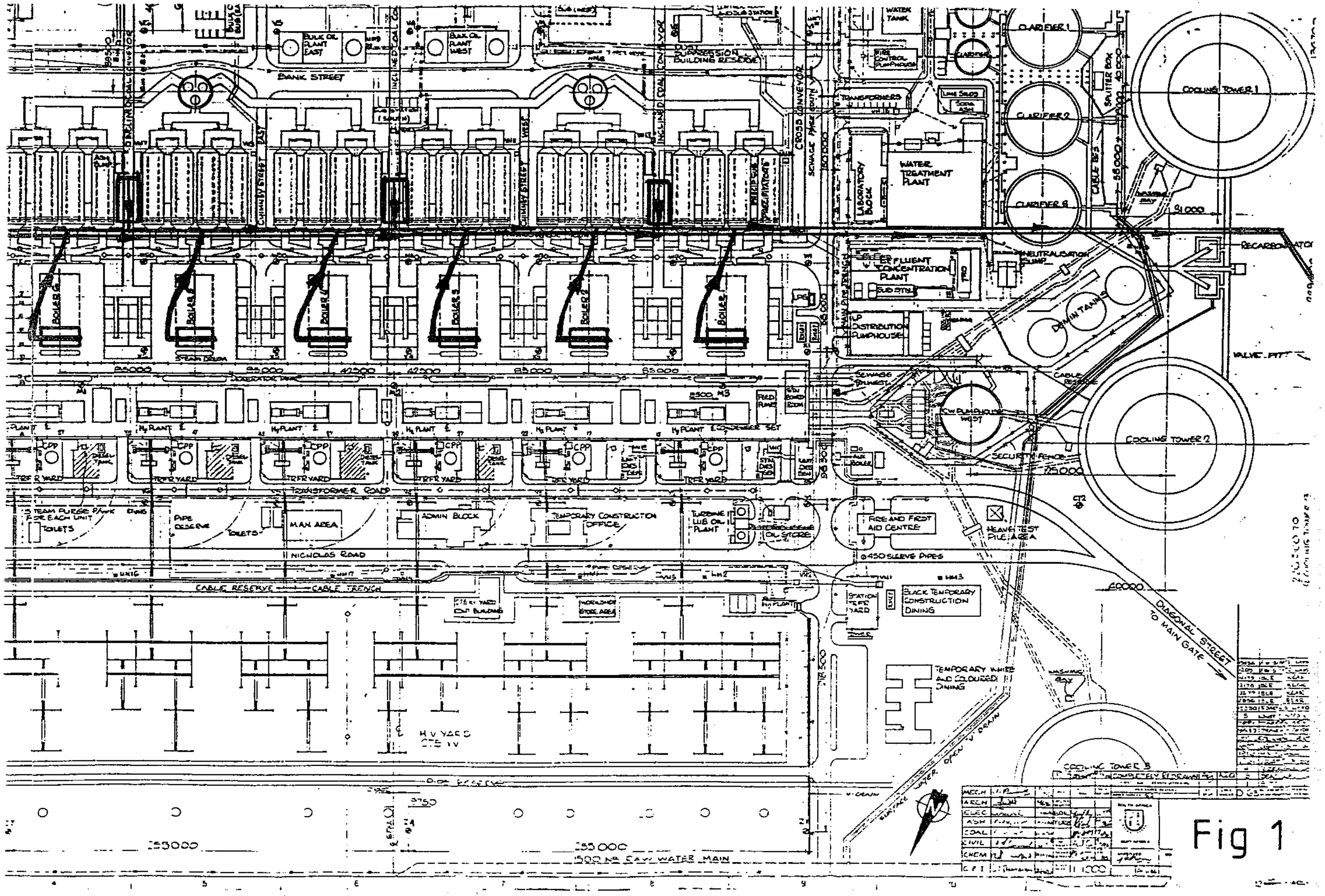
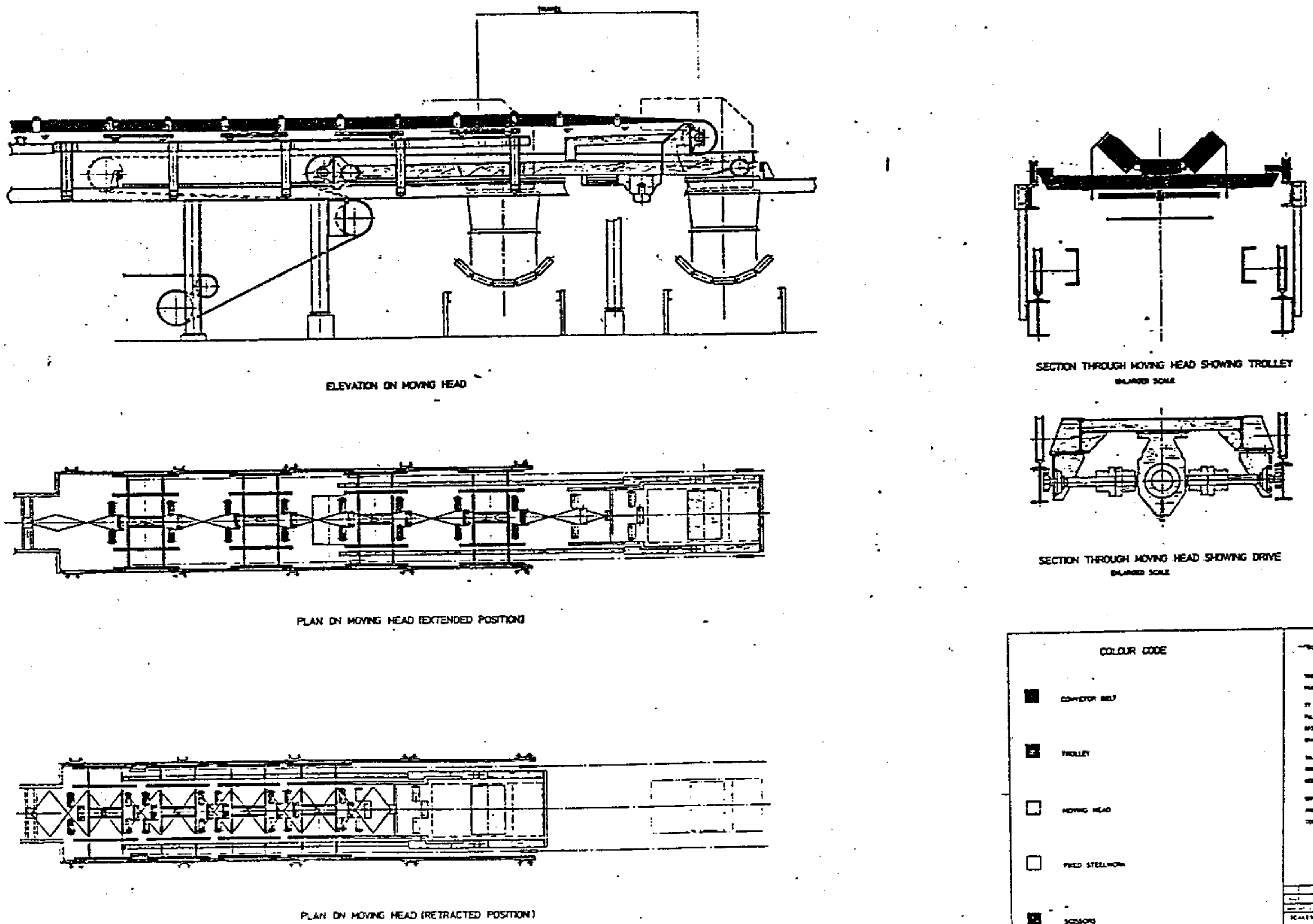

COOLING TOWER 1
COOLING TOWER 2
COOLING TOWER 3
CLARIFIER 1
CLARIFIER 2
CLARIFIER 3
SPLITTER BOX
CABLE RES
WATER TREATMENT PLANT
LABORATORY BLOCK
TRANSFORMERS
FIRE CONTROL PUMPHOUSE
WATER TANK
DUST SUPPRESSION BUILDING RESERVE
BANK STREET
BULK OIL PLANT EAST
BULK OIL PLANT WEST
INCLINED COAL CONVEYOR
CROSS CONVEYOR
SEWAGE PIPE SOUTH
CHIMNEY STREET EAST
CHIMNEY STREET WEST
PRECIPITATORS
BOILER 1
BOILER 2
BOILER 3
BOILER 4
BOILER 5
BOILER 6
STEAM DRUM
DEAERATOR TANK
H2 PLANT
CONDENSER SET
CPP
TRFR YARD
TRANSFORMER ROAD
STEAM PURGE P/PARK FOR EACH UNIT
TOILETS
PIPE RESERVE
MAN AREA
ADMIN BLOCK
TEMPORARY CONSTRUCTION OFFICE
TURBINE LUB OIL PLANT
OIL STORE
FIRE AND FIRST AID CENTRE
HEAVY TEST PILE AREA
NICHOLAS ROAD
CABLE RESERVE
CABLE TRENCH
PIPE RESERVE
Ø450 SLEEVE PIPES
STATION TRFR YARD
BLACK TEMPORARY CONSTRUCTION DINING
TEMPORARY WHITE AND COLOURED DINING
WORKSHOP STORE AREA
H V YARD
DIAGONAL STREET
TO MAIN GATE
SECURITY FENCE
RW PUMPHOUSE WEST
DEMIN TANKS
NEUTRALISATION SUMP
EFFLUENT CONCENTRATION PLANT
LP DISTRIBUTION PUMPHOUSE
MAIN PIPE TRENCH
SEWAGE TUNNEL
CABLE RESERVE
VALVE PIT
RECARBONATOR
SURFACE WATER OPEN V DRAIN
1500 NB CAW WATER MAIN
155000
155 000
85000
42500
53000
31000
40000
56000
75000
60000

Fig 1




COLOUR CODE

- CONVEYOR BELT
- TROLLEY
- MOVING HEAD
- FIXED STEELWORK
- SCISSORS

MOVING HEAD

9-825

Fig 2

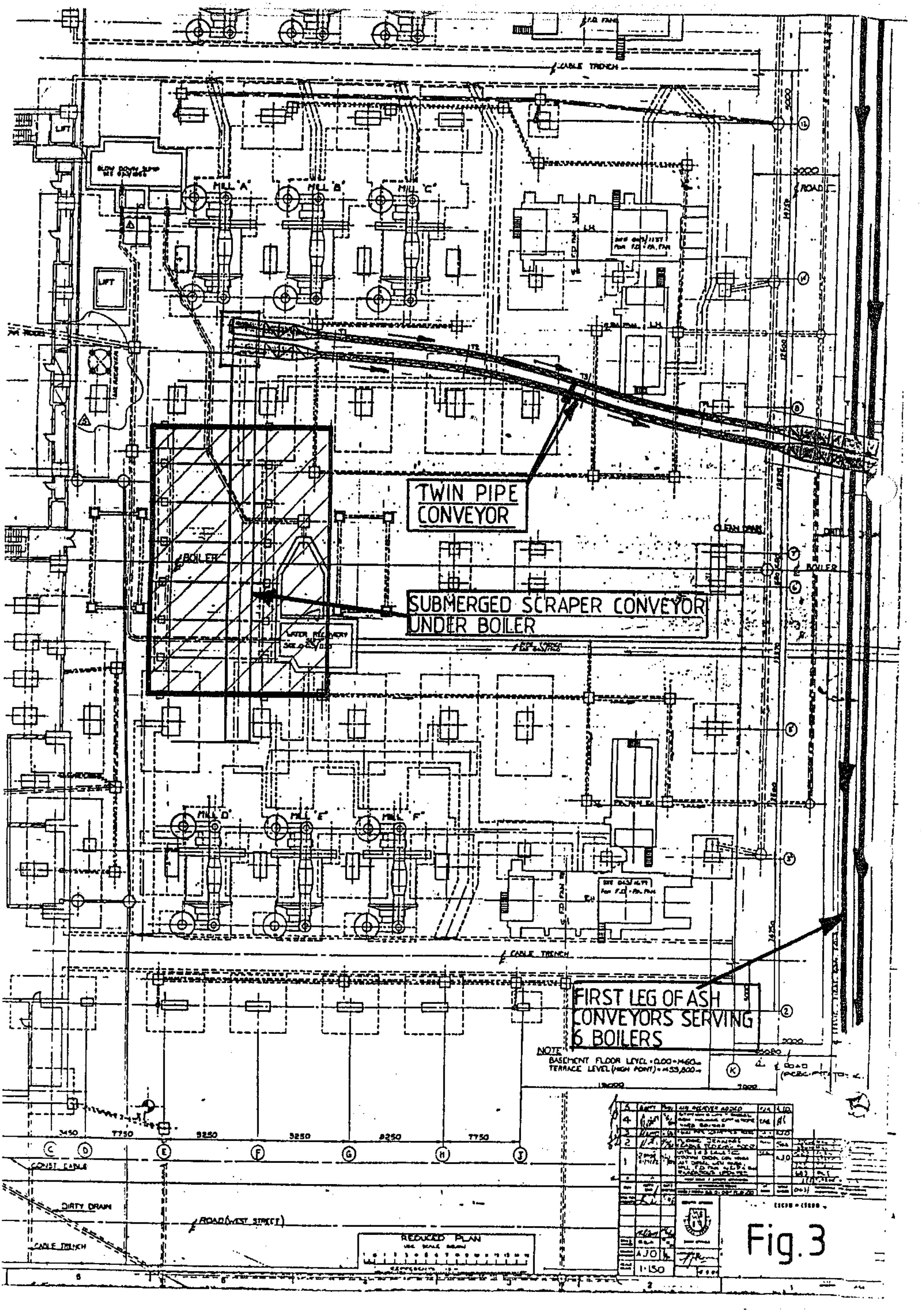

TWIN PIPE CONVEYOR
SUBMERGED SCRAPER CONVEYOR UNDER BOILER
FIRST LEG OF ASH CONVEYORS SERVING 6 BOILERS
MILL "A"
MILL "B"
MILL "C"
MILL "D"
MILL "E"
MILL "F"
BOILER
LIFT
CABLE TRENCH
ROAD
CLEAN DRAIN
DIRTY DRAIN
ROAD (WEST STREET)
REDUCED PLAN
NOTE
BASEMENT FLOOR LEVEL = 0.00 = +460
TERRACE LEVEL (HIGH POINT) = +53,800
3450
7750
9250
9250
9250
7750
AJO
1:150

Fig.3