

# SOME IMPROVEMENTS IN THE DESIGN AND OPERATION OF COAL FIRED BOILERS

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This paper deals with five problems experienced in the operation of coal fired boilers and the methods by which these problems were overcome. The paper is divided into five sections, each dealing with a specific problem, although some of the problems are inter-related. Drawings are diagrammatic but charts shown are from the boiler instruments.

- 1.00 Superheater tube chokages and failure
- 2.00 Coal grading and selection
- 3.00 Chemical additive to coal
- 4.00 Economiser tube chokages and flyash arresters
- 5.00 The use of accumulators

## 1.00 Superheater tube chokages and failure

In any factory where process steam is used and the condensate returned as boiler feed, there exists the eternal problem of contamination of the feed water by the product being processed. If such product is soluble and deposits out on being subjected to heat there exists the constant problem of blistering, bulging or burst boiler tubes due to overheating. If the product also causes priming or foaming then there is the constant and greater probability of superheater tube failure. Sugar is such a product.

Under normal boiler operating conditions wet steam leaves the boiler drum at a dryness fraction of  $\pm .95$  to  $.97$ . This means that the superheated tubes have to dry the steam before a temperature increase may be obtained.

Should the boiler prime or foam then a heavy concentration of contaminated water enters the superheater via the wet header, and the product of contamination is deposited out on the superheater tubes. This contamination or deposit lodges on the tube walls and acts as an insulator allowing the steel to overheat, thus leading to a superheater tube burst. The more frequent failure is where the tubes hang from overhead header boxes, the bend in the bottom of the tubes forming an ideal trap for contaminated moisture to lodge before flashing. Any build up in deposit will starve the tube of the cooling effect of the steam passing through and the tube will overheat and fail. It is necessary to bear in mind that the pressure differential between the wet and dry headers is only of the order of one or two lb./in.<sup>2</sup>.

Where there exists the possibility of contamination of condensate from the process product the ideal is to turn the condensate away from the feed tank before the boilers are contaminated. It is not always possible to do this in time unless an automatic device is fitted to the condensate lines, the device being actuated by a conductivity meter in the condensate tank.

Where boiler water has been contaminated and the boilers prime or foam a simple but very effective method of removing contaminated carry-over before it reaches the superheater tubes has been utilised at the Refinery, and this is entirely automatic, requiring no maintenance. This consists of a baffle plate type drier with a collection bottle at floor level, a drain and a steam trap mounted half-way up the bottle. The steam trap is mounted at this height so that any sediment which may enter the bottle will precipitate to the bottom and not foul up the steam trap and prevent its operating.

Any carryover from the steam drier strikes the baffle plate and runs down the plate to the gutter which draws moisture off to the section below the perforated plate. This moisture travels down the pipe to the collection bottle on the floor and discharges through the steam trap into a protected drain. This unit must be approved by the Inspector of Machinery and any welding is to be done by an "A" class welder. Proportions of this unit are to be related to the design pressure of the boiler.

## 2.00 Coal grading and selection

Most boilers are designed to operate on a particular type and grading of coal. Any variation from the designer's specifications can lead to operating problems.

Considerable difficulty had been experienced in operating the boiler plant on coal which had the classification of "Washed Mixed Smalls". This classification may appear reasonable on paper, but the actual product delivered varied considerably from its specification as is shown in the accompanying table with relevant comments. Percentages are by weight.

For obvious reasons the source of supply may not be quoted.

TABLE 1  
Coal grading as received

Sample No.	On $\frac{1}{2}$ "	On $\frac{1}{4}$ "	On $\frac{1}{8}$ "	Thru $\frac{1}{8}$ "	Comments
1	21.7	30.7	26.3	21.3	
2	Nil	19.3	31.7	49.0	
3	67.8	28.7	3.38	0.22	
4	21.0	31.0	23.9	24.1	
5	4.2	12.2	39.1	44.5	Good steam Light smoke
6	67.2	27.46	2.76	2.58	Heavy smoke Poor steaming
7	Nil	44.2	48.6	7.2	Smokeless Easy steaming Anthracite as ordered

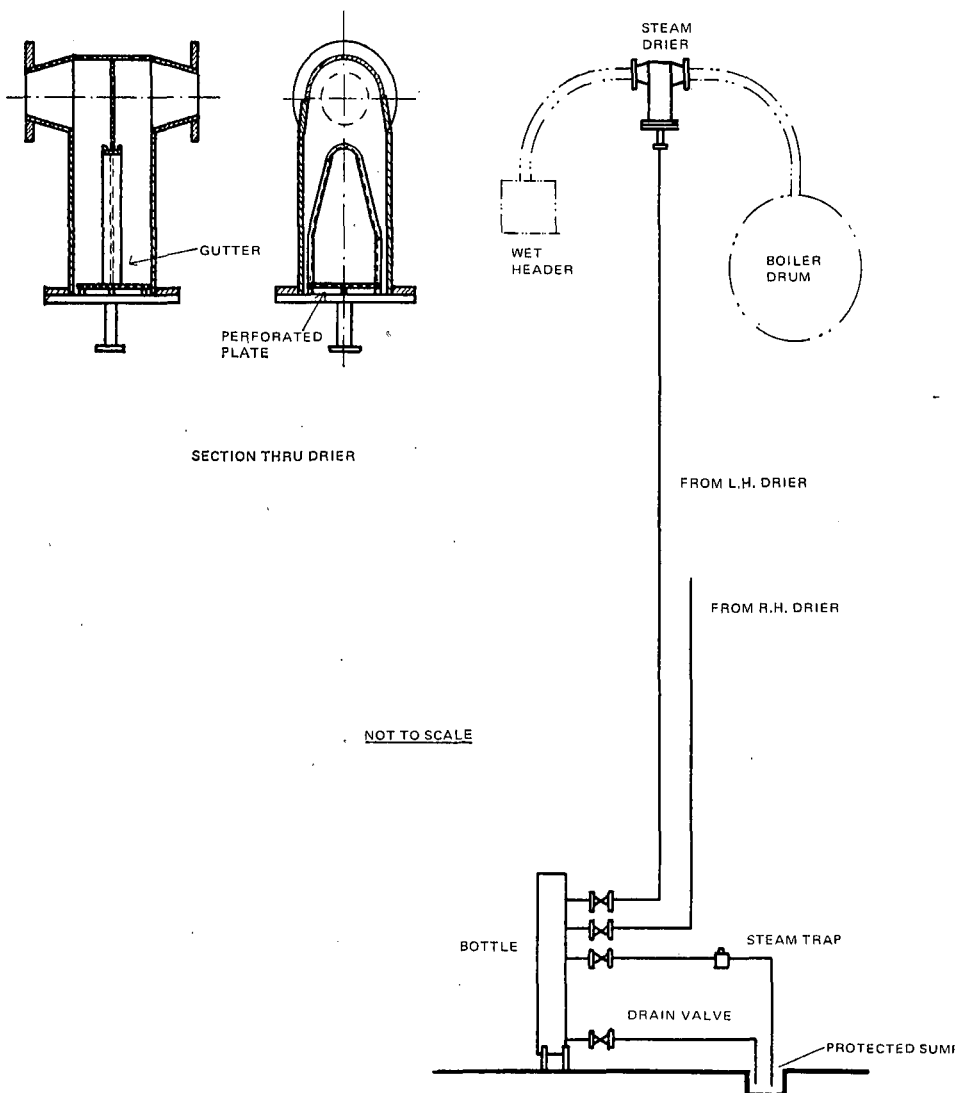


DIAGRAM NO. 1: Sketch of drier, bottle and steam trap.

TABLE 2

Calorific Values Composite Samples (Weekly).

Sample 1	13363	BTU/lb.
Sample 2	13025	BTU/lb.
Sample 3	13413	BTU/lb.
Sample 4	11548	BTU/lb.

Sample 4 shows a drop of 12½% which means naturally that more coal must be burned for the same steam output and with a greater quantity of ash for disposal.

The difficulties which were experienced in using these fuels consisted of *inter alia*:

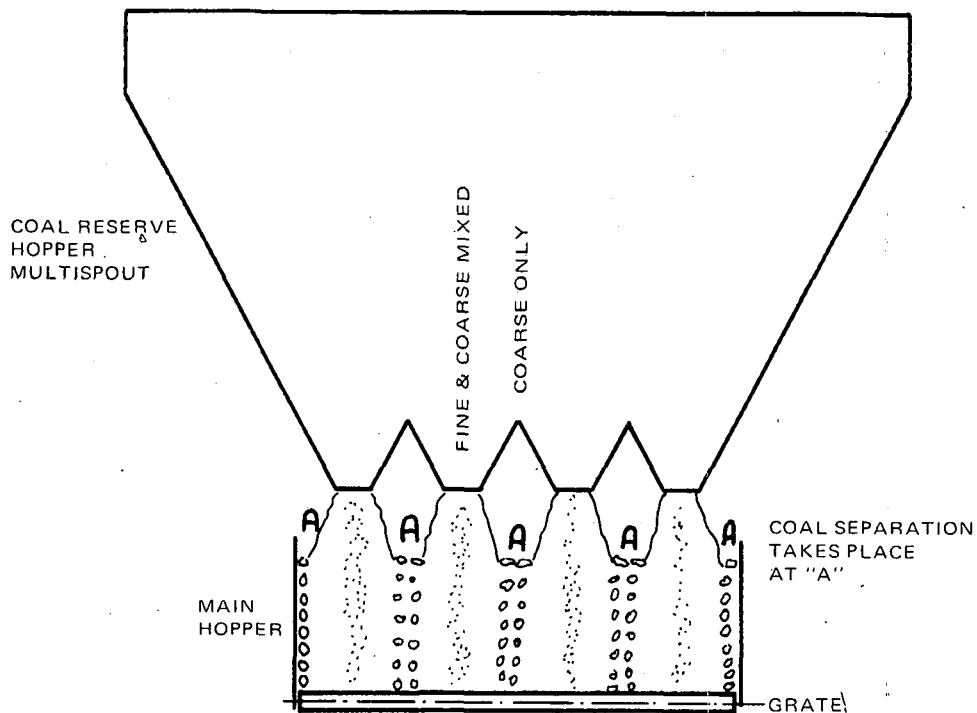
1. Poor ignition
2. Low steam production
3. Heavy smoke
4. Fouling up of generator tubes
5. Heavy clinker
6. Incomplete and inefficient combustion

The coal was supplied to the chain grates of the boilers by means of a coal reserve multispout hopper which fed into the main hopper of the boiler thence on to the grate.

As the coal continued to trickle downwards under the demand influence of the chain grate below, the coal emerging from the spouts allowed the larger

pieces to run down the side of the cones formed while the finer material remained static, this being coal separation. This caused a variation in the porosity or permeability of the coal on the grate with resultant draught problems.

As the coal ignited and burnt the forced draught naturally took the path of least resistance, and the major portion of air passed up through the section of grate covered by the larger pieces which had the greater porosity. Since the draught was applied at a pre-determined pressure and volume and since it could only slightly penetrate the dense mass of fines, there was an increased volume and consequently an increased velocity of air passing through the sections of larger pieces of coal. Any finer particles adhering to or separating off these larger pieces of coal then ignited and were carried by the high velocity draught up through the furnace and deposited on the overhead generating tubes while still in their plastic state. When striking the comparatively cooler surface of the tubes they were chilled and adhered to this surface, this being the beginning of birdnesting. This action had a cumula-



**DIAGRAM NO. 2:** Diagram of coal reserve hopper (multi-spout), main hopper and coal on grate.

tive effect until ultimately all tube passages were choked. See photograph "A".

The charts shown indicate the progressive deterioration of steam flow from the boiler due to fouling up of the tubes by birdnesting.

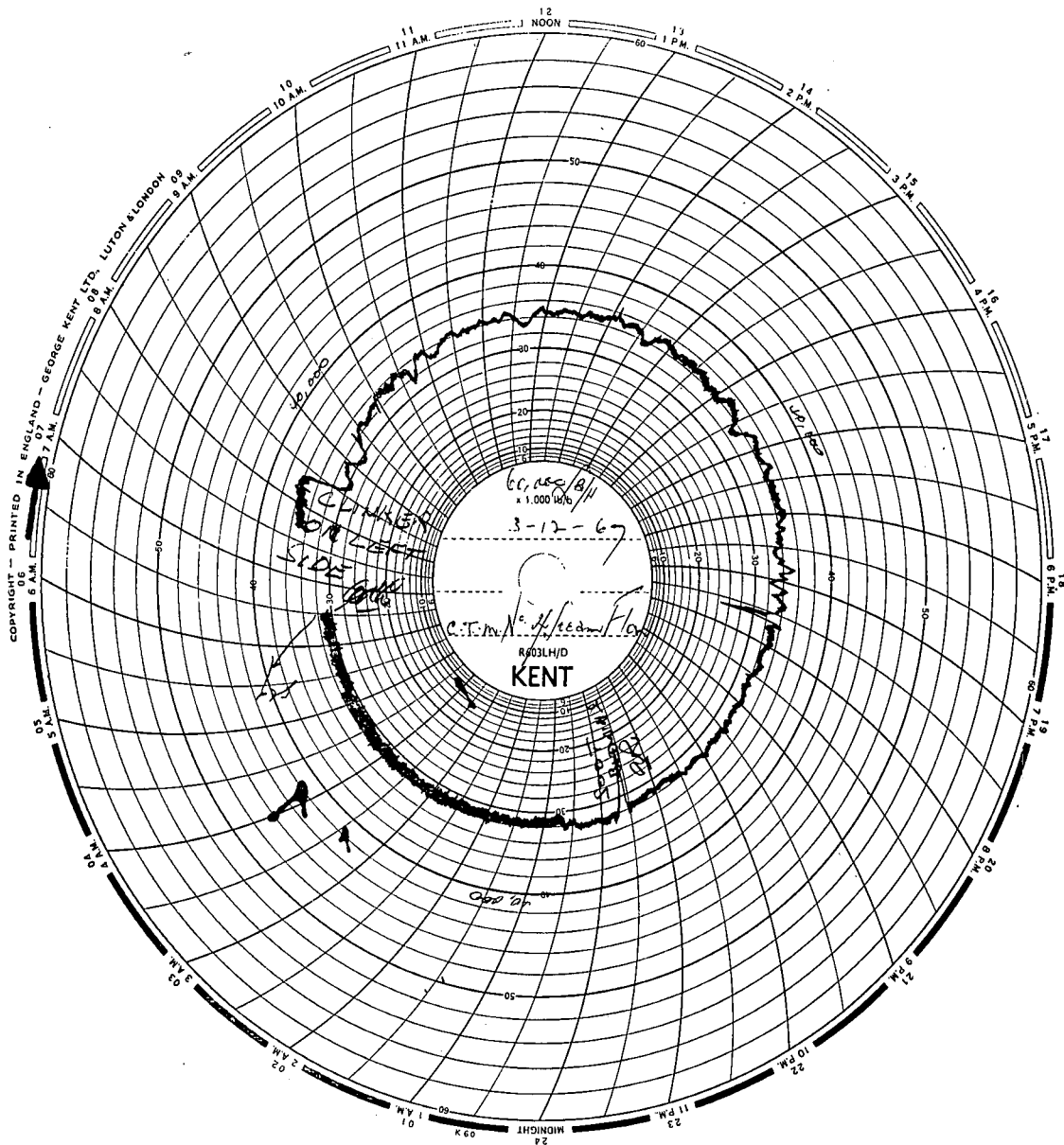
Chart No. 1 has a comment by the boiler attendant that the boiler was choking up. This was after it had been thoroughly cleaned at the weekend and had been steaming only five days. As can be clearly seen from charts 1 to 5 the boiler was becoming progressively choked up until it was no longer a proposition to keep it on range. Accordingly, on 5th December 1967, a Tuesday, the boiler was taken off for cleaning. Due to the choked up nature of the tubes it was most difficult to lower the temperature in the furnace though all doors were opened for there was no through draught even though the induced draught fan was kept running.

The boiler cleaners were induced to enter the furnace under appallingly hot conditions, break out some of the birdnesting and come out for a spell. They were not allowed to remain in the furnace for more than three minutes at a time and had to sit outside to cool off for at least ten minutes. If any cleaner showed any reaction to the high temperature in the furnace he was kept out for a longer period. By working in relays and keeping a check for heat exhaustion it was possible to have the boiler back on range in the incredibly short time of nine-and-a-half hours from shut down to full steaming. It must be borne in mind that it was December in Durban — a normally hot time of the year. These boiler cleaners did sterling work in cleaning the boiler.

As can be seen from Chart No. 5 the boiler gave its maximum steam output again after cleaning.







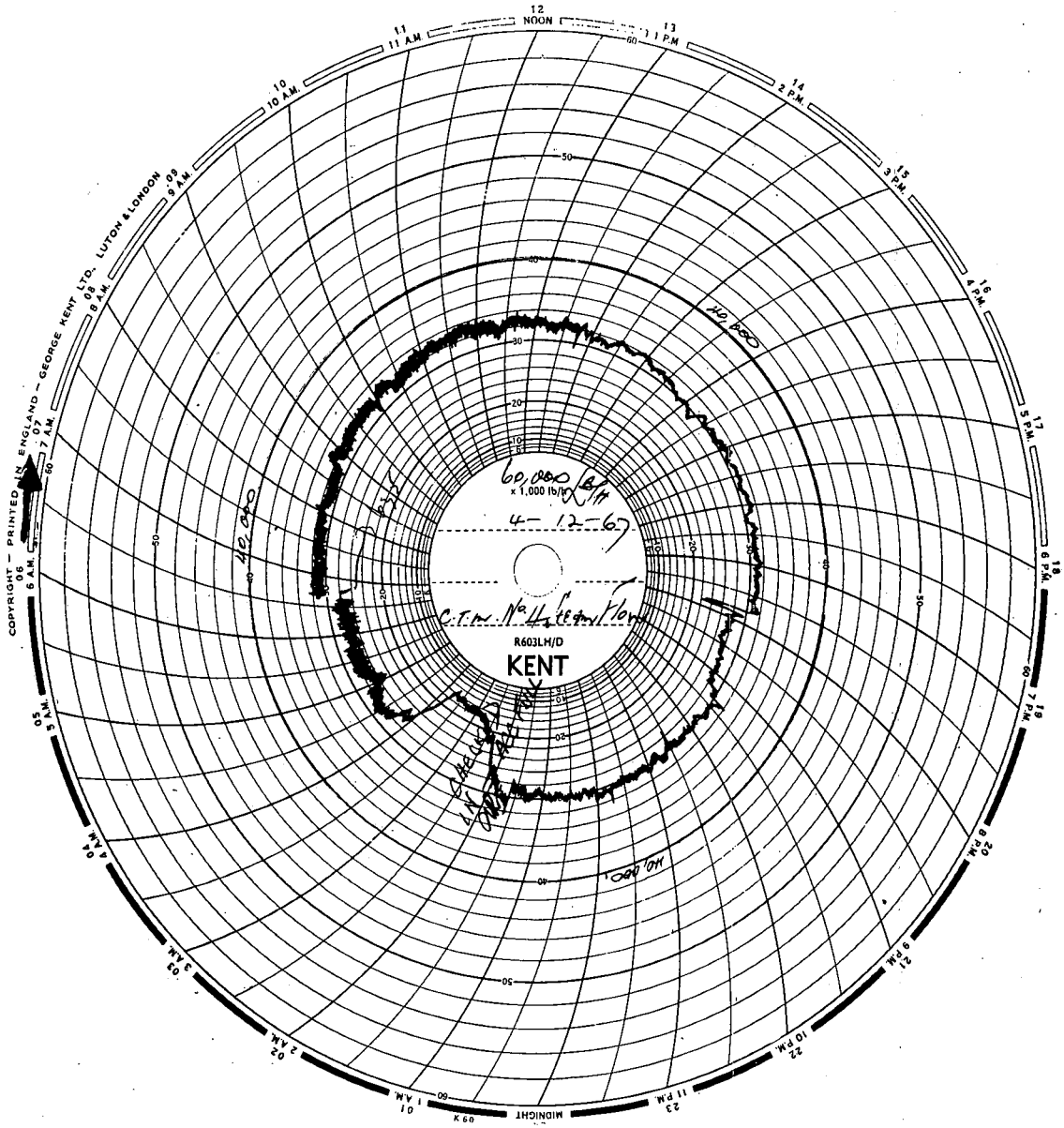


CHART 4

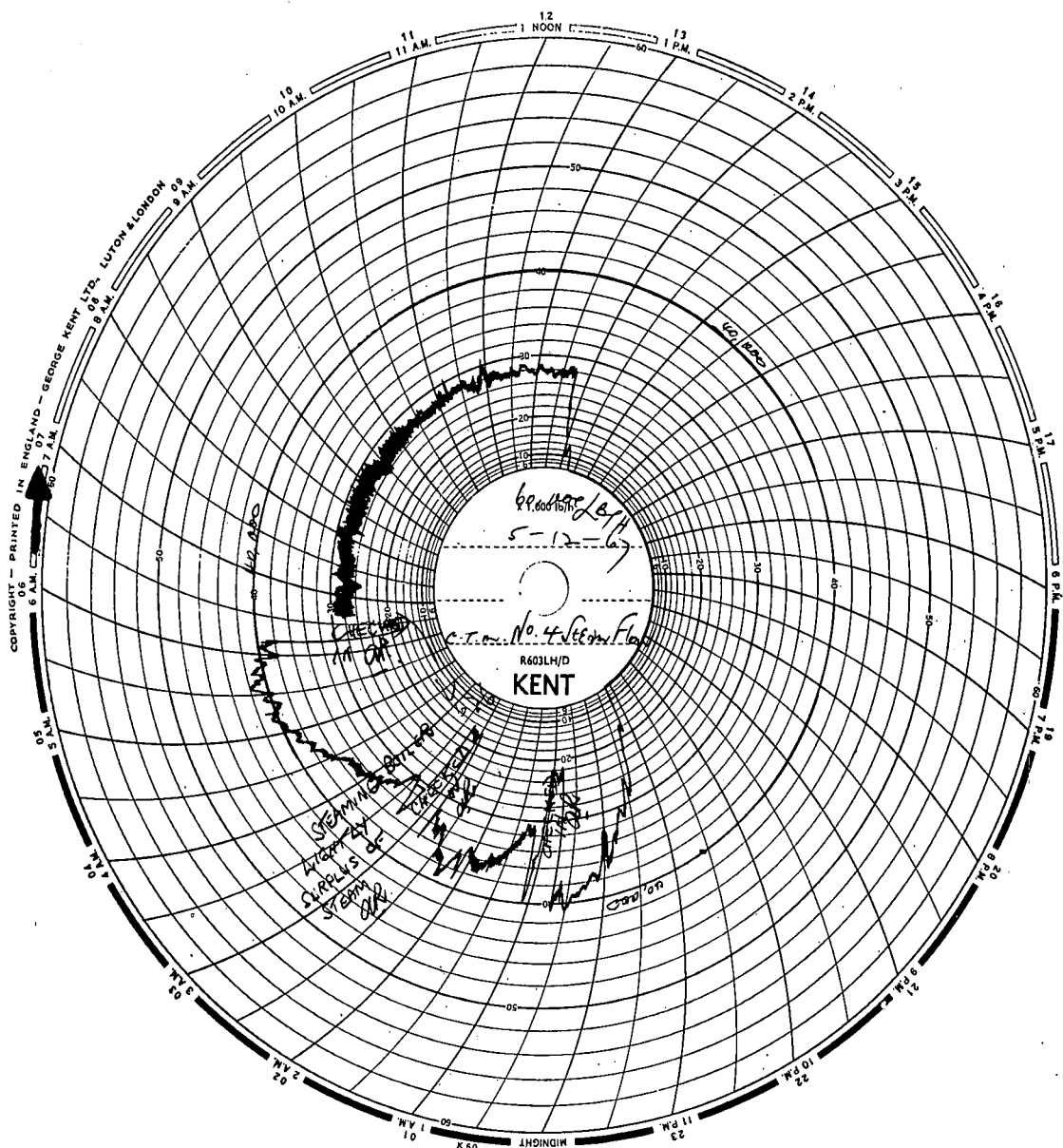


CHART 5

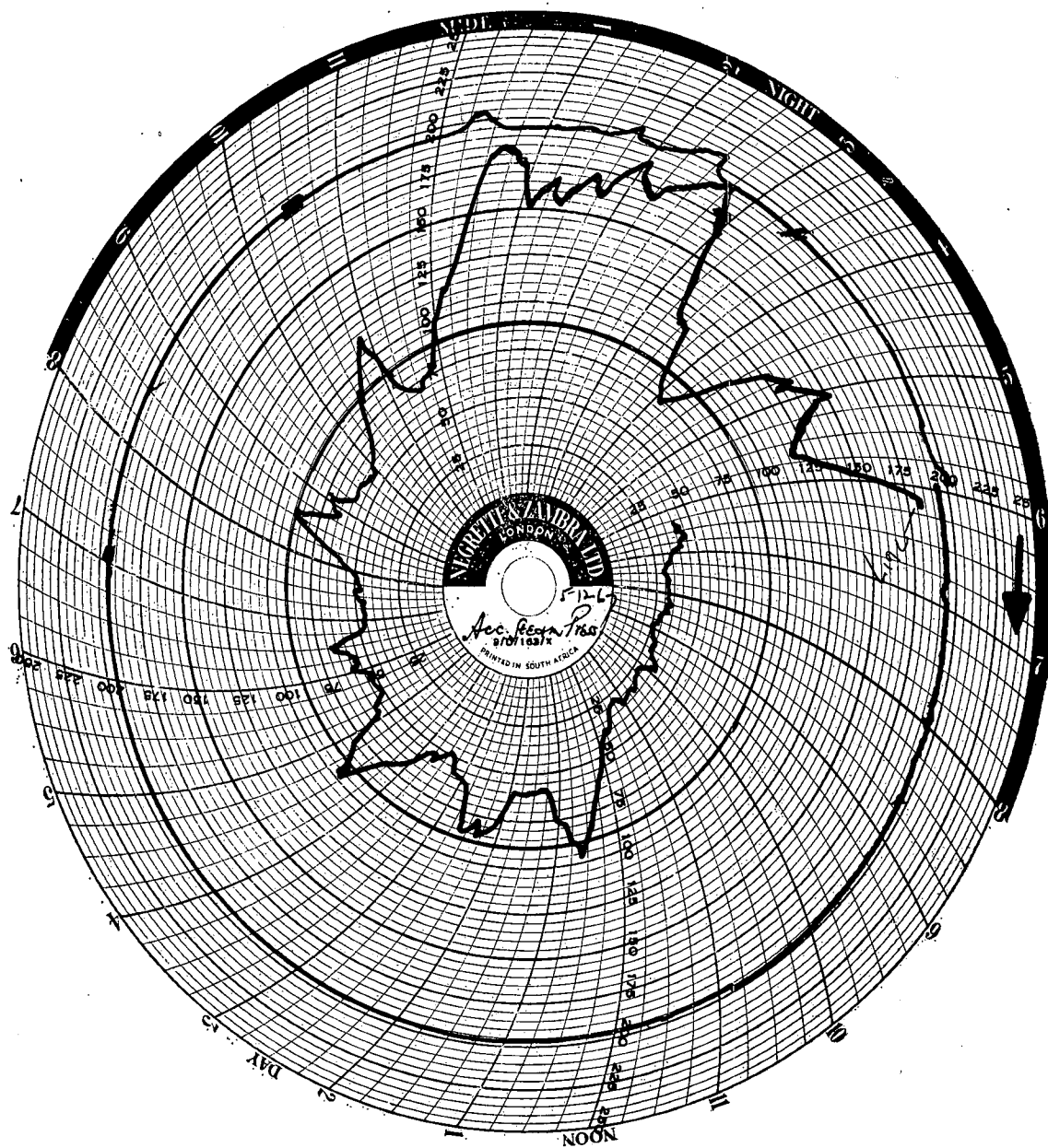


CHART 6

Dealing with the effect of coal separation on combustion, it will be seen from diagram No. 3 that initially ignition was good, but as the grate moved forward the combustion was better through the larger particles and consequently this coal had burnt out to ash at section marked first ash. The draught now had an opportunity of rushing up through this ash and failed to penetrate the portion where the fines were located, consequently this section was starved of air and failed to burn, with the result that it passed over the finger bars unburnt and gave the high percentages of combustibles in the ash of 27% and even higher.

The heat passing over the mass of fines tended to fuse the surface and prevent the portion beneath from reaching combustion temperature and burning. A most uneconomical method of fuel consumption.

tribution of forced draught through the entire bed was obtained. Draught control could now be effectively applied by adjusting the appropriate under-grate louvres and a reasonably straight line was seen across the width of the bed where the hot coals ended and the ash began. The positions of this line or bed length could be lengthened or shortened by normal boiler control, the governing factor being the percentage of  $O_2$  and consequent  $CO_2$  in the flue gases.

Thanks mainly to the co-operation of the Natal Associated Collieries a source of supply was located which could and would supply the grade, quality and quantity of coal which was required.

The coal gave good ignition, good combustion and good ash results. There was only one disadvantage and this was the tendency for the ash to clinker.

NOT TO SCALE

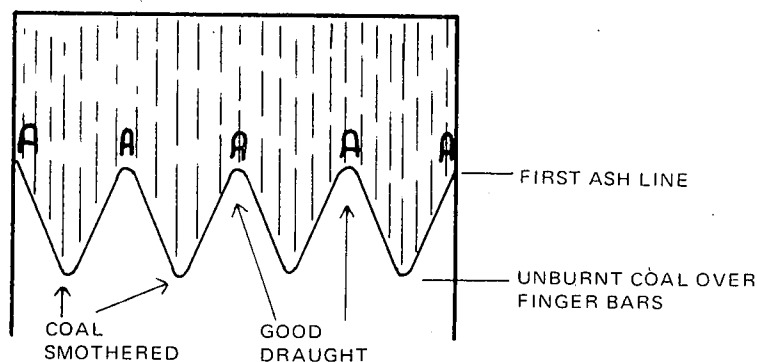


DIAGRAM NO. 3: Plan of grate showing fingers of unburnt coal.

An experiment was tried of mixing Anthracite and Bituminous coal in the proportion of 1 to 4 respectively. It was reasoned that the slower ignition properties of the anthracite would give a higher temperature on the grate in the later stage of combustion and that this would assist in the burning of the finer particles.

In theory this seemed correct but in practice it was only partially successful since, in order to obtain complete combustion in the time allowed by the speed of the chain grate,  $\pm 28$  ft./hr., it had to be of a smaller size than peas, and this tended to aggravate the problem of fines and consequent smothering of the fuel bed. Proportions of 1 in 3 and 1 in 5 were also tried but with the same unsatisfactory results.

It will be appreciated that with unequal distribution of air to the burning coal due to the varying degrees of porosity or permeability on the grate there tended at times to be heavy dark smoke from the stacks. This was both inefficient combustion and a health problem in a smog conscious city as well as being uneconomical.

The ultimate solution was found when a coal of pea size grading was obtained. Incidentally, these boilers were designed to burn peas.

With coal of this size in the hoppers no apparent separation of particles was noted and an even dis-

tribution of forced draught through the entire bed was obtained. Draught control could now be effectively applied by adjusting the appropriate under-grate louvres and a reasonably straight line was seen across the width of the bed where the hot coals ended and the ash began. The positions of this line or bed length could be lengthened or shortened by normal boiler control, the governing factor being the percentage of  $O_2$  and consequent  $CO_2$  in the flue gases.

Initially the clinker formed was of comparatively small size, about 4 inches square and about half-an-inch to 1 inch thick. This clinker could be handled by the ash hopper and the paddle ash units. The clinker-forming property of the coal gradually deteriorated until eventually it was coming up to the finger bars at the end of the grate in a plastic state and instead of rising over the finger bars it was pushing them away from the grate. In a number of instances it broke the bottom lugs of the finger bars which then fell into the ash hopper and had to be removed from the side clearing door. Looking through the side inspection door of the boiler between the water tubes the clinker could be observed as it travelled along on the chain grate, lodged against the finger bars and gradually buckled upwards, holding back clinker behind it. Some of the clinker would buckle upwards until vertical and then slowly bend backwards into the boiler like a stick of soft toffee on a hot day.

Clinker ultimately formed on the grates to such a size as to become unmanageable. It was forming in blocks about three feet square and six inches to eight inches thick. It was hard and could only be removed from the ash hopper through the side clearing door and then only after it had been broken up by means of heavy bars. This heavy undue extra work was telling on the boiler staff who were reach-

ing the stage where they felt the job was not worth having — and they could not be blamed for this since they spent all their available time on ash removal to the exclusion of their other duties.

A complaint was lodged with the supplier. The manager flew down to investigate our problems, enquired when they started and established the fact that our supply was now being mined from another pit of the same mine. Instructions were given for all coal to be supplied from the initial pit head which supplied the original consignments and the clinker reverted back to its original manageable proportions.

The boiler plant was now once again in the favourable position of being able to steam for a fortnight without undue loss of steam output and manageable clinker. Though the position was now better than it had ever been in the previous three years it was still not considered entirely satisfactory since the large volume of deposit had to be removed from the tubes on the fortnightly shutdown weekend and clinker still periodically damaged or burnt finger bars and/or their tips.

It must be borne in mind that this boiler plant operates at between 90% and 115% of designed rated output. This is considered quite safe since an accurate check is kept on the boiler water condition.

The troubles which were being experienced on the firing side of the boiler now began to raise the question as to whether it was not the high rate of steaming which might be causing the chokages and clinker.

**TABLE 3**  
Report on Analysis of Deposit and Clinker

Sample No.	Coal Ash 67/210 B	Deposit on Tubes 67/311
% Ash	12.9	100.0
% Si O <sub>2</sub>	41.1	34.4
% Al <sub>2</sub> O <sub>3</sub>	28.0	26.7
% Fe <sub>2</sub> O <sub>3</sub>	11.5	20.0
% P <sub>2</sub> O <sub>5</sub>	0.35	1.2
% Ti O <sub>2</sub>	1.38	1.68
% CaO	9.6	8.9
% MgO	2.08	3.00
% K <sub>2</sub> O	1.14	1.05
% Na <sub>2</sub> O	1.69	3.33
% SO <sub>3</sub>	2.98	0.15
Ash Fusion Temperature	1281°C	1252°C

The composition of the coal ash differs considerably from that of the deposit. With the high iron and calcium content of both, a fairly low ash fusion temperature is to be expected.  
(The deposit on the tubes is shown in photograph "G")

### 3.00 Chemical additive to coal

(See photographs A - G)

As was mentioned previously a close liaison existed between ourselves and the coal suppliers, who forwarded us a publication regarding fuel additives for coal firing of boilers (James<sup>1</sup>). The history of boilers shows that there are, and have been, many innovations, all with extravagant claims, regarding feed water treatment or fuel additives. All engineers are subjected to the efforts of salesmen and represen-

tatives intent on selling their own brand of product. Boilers, because there are so many thousands in use in South Africa, are an open field for various suggested changes of treatment on the water or fire side. Numerous gimmicks have been tried but how many have lasted the test of time? It is for this reason that a certain wariness was shown towards this publication regarding fuel additives.

Ultimately it was agreed that the test of this additive could be made on this plant, with the proviso that, should it be successful over a period of time, the additive and feeder would be incorporated into the fuel system, but should it be unsuccessful it would be removed and no charges incurred. This was agreed to and arrangements were made for it to be added to our fuel for test purposes.

It was agreed that only one of the five main boilers would be treated for test purposes, this boiler being the one which tended to choke up sooner and more rapidly than the others.

The additive, copper oxychloride, was obtained in the form of a powder and initially was fed on to the coal on the conveyor at the rate of a half-a-pound per ton and the initial results appeared to be very satisfactory. One interesting point is the fact that the residue left on the belt and in the boot of the bucket elevator was carried through to the next boiler in the coaling up system, and at the weekend shutdown a distinct line could be seen where the residue was carried through on the flames. The mark on the side wall tubes and the slag on the rear arch all showed the reaction which was obtained with this additive. This reaction was similar but in a milder form to that obtained in the boiler under test.

The combustion chamber of the boiler under additive test gave the following results:

**Ignition Arch.** Brickwork subjected to the flame was clean. Brickwork in the combustion chamber portion of the arch had its normal hard clinker.

**Rear Arch.** Brickwork was covered in a hard clinker, which was there before the test, but the surface of this hard clinker was becoming soft, porous and friable. It could be rubbed off with the palm of the hand.

**Side Walls and Tubes.** The tubes at the rear end of the boiler were clean with a copperish colour. The tubes near the ignition arch were clean above the water wall boxes but higher up they still had a clinker coating.

**Overhead Generating Tubes.** Reasonably clean with only slight evidence of build-up between the tubes, and this appeared to be softer and easier to remove.

**Furnace Condition and Temperature.** On the Sunday morning when the cleaners went in it was substantially cooler and cleaner. Less dirt was removed, and in a shorter time, under more favourable working conditions for the men.

**Clinker on Grate** tended to be smaller and broke up easily.

The first week's results were very encouraging and the test was continued but only on the one boiler.

After some three or four weeks it was found that

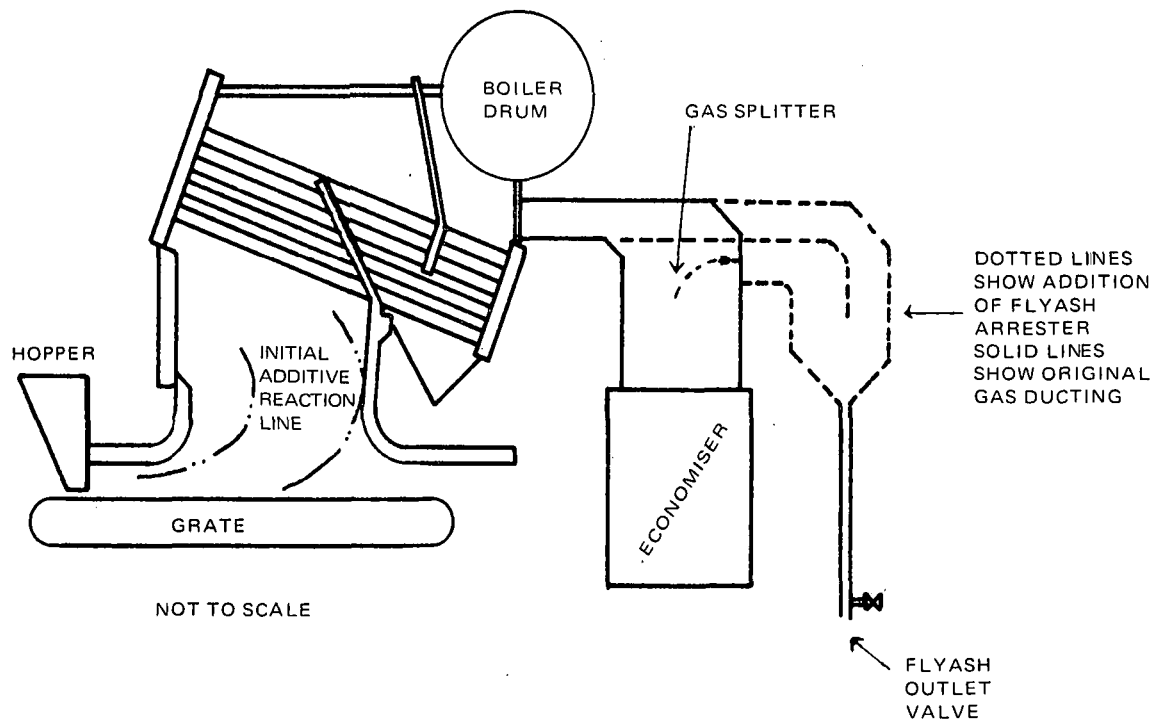


DIAGRAM NO. 4: Section through B & W showing reaction of additive.

on the boiler under additive test the entire furnace was now clean and even the top brickwork on the ignition arch was becoming cleaner. All tubes were clean, rear arch was clean down to the brickwork and overhead generating tubes showed no sign of choking up.

Sootblower holes which normally choked up with clinker were also clean.

At this stage it was decided to apply the additive to all boilers and the results on the other boilers are as satisfactory as the original boiler on which the test was conducted.

A peculiar side effect of the additive of copper oxychloride was the fact that the normal dosage to No. 5 Boiler had to be discontinued. The dust which was carried over in the  $\text{CO}_2$  gas used in the Carbonatation process now appeared to have a property which caused it to adhere to the cones on the MUSGRAVE filters, and it failed to shake loose with the normal wrapping. When the normal dosage of copper oxychloride was stopped, this dust reverted to its original property and was capable of being shaken off with the normal wrapping mechanism.

As has been stated before, there is a residue of copper oxychloride on the conveyor belt and in the boot of the bucket elevator, which is carried through to the No. 5 Boiler and this is, or appears to be, sufficient to maintain this boiler in a clean condition. One other point is the fact that No. 5 Boiler is set to give a fixed output of steam per hour, slightly above its rated design capacity, and any alteration of boiler output necessary to maintain the accumulator pressure within specified limits is done on the other boilers.

Steaming today is no problem. There are no boiler chokages and less than half the units of labour are brought in for boiler cleaning over the weekend. These units which are brought in are also used

for packing the fires ready for the lightup, and cleaning the boiler house. The amount of dirt removed is small, the working temperature in the furnace on Sundays is now substantially cooler. There is no clearing of chokages from the generating tubes and also very important is the fact that the furnace and arch brickwork do not require to be shaved by the boiler bricklayers; this latter considerably extends the life of the furnace bricks, which are expensive.

The financial saving to the Company is substantial but no costs have been extracted as there are too many hidden savings which cannot be calculated, but a list of savings is shown hereunder.

- (a) Saving in units of labour for cleaning purposes;
- (b) Greater output per cleaner due to the fact that more time is spent cleaning rather than recovering from the excessive heat in the furnace;
- (c) Greater heat transfer due to cleaner external conditions of tubes;
- (d) Less damage done to brickwork due to shaving of bricks;
- (e) Less time spent by boiler bricklayers patching damaged bricks;
- (f) No longer any necessity to slice fires, consequently less damage to brickwork by boiler men;
- (g) No reduction of production due to shortage of steam when boilers choke and have to be taken off during week for cleaning.
- (h) Boiler attendant is able to spend more time controlling the boilers properly and steaming them efficiently.
- (j) Better combustion, no smoke and consequently better thermal efficiency and coal saving.

Incidentally, there are two mixtures of copper oxychloride obtainable. They are marketed under the name of Fisons Blitox 50% and Fisons Blitox 5%.

The 50% mixture is a rose fungicide and the 5% mixture is a tomato fungicide.

Pound for pound the tomato mixture was cheaper than the rose mixture when considering the copper oxychloride content but it was found that the boilers responded better to the rose treatment.

The present rate of dosage is 27 ppm of 50% copper oxychloride or 13.5 ppm of copper oxychloride by weight.

The cost of treatment of the additive copper oxychloride 50% mixture known as Fisons Blitox is 2.45 cents/ton coal consumed at this factory.

TABLE 4  
Blitox "50"

Composition by weight	
Copper oxychloride (50% metallic content)	90%
Inert ingredient (Spreader and sticker)	10%

**4.00 Economiser tube chokages and flyash arresters**

Considerable difficulty had been experienced at this boiler plant in maintaining the finned econo-

miser tubes in a clean condition. The normal routine was to sootblow them once per shift and water-wash every second day. Photograph H indicates the condition of the tubes removed from the economiser at the end of a year's steaming under the above conditions.

In engineering it is essential to be open-minded on all subjects and commonsense is a pre-requisite of good engineering.

During our annual shutdown it was observed that the finned tubes on the economiser of the Stirling boiler were clean whereas those on the B & W C.T.M. boilers were very dirty. All boilers used the same coal and steamed under similar conditions so the problem now was to establish the reason for the economiser being clean on the Stirling boiler. This economiser was an addition to the boiler and not part of the original installation.

Examining the gas flow through the boiler it was noticed that the gases changed direction before entering the economiser and the lower portion of this last pass was always full of flyash. This then was the principle which had to be applied to the B & W boilers and it has been achieved as shown in diagram 4. Diagram 5 shows the gas flow in the Stirling boiler.

This modification to the B & W boilers was made on one boiler only as a test and when this was found

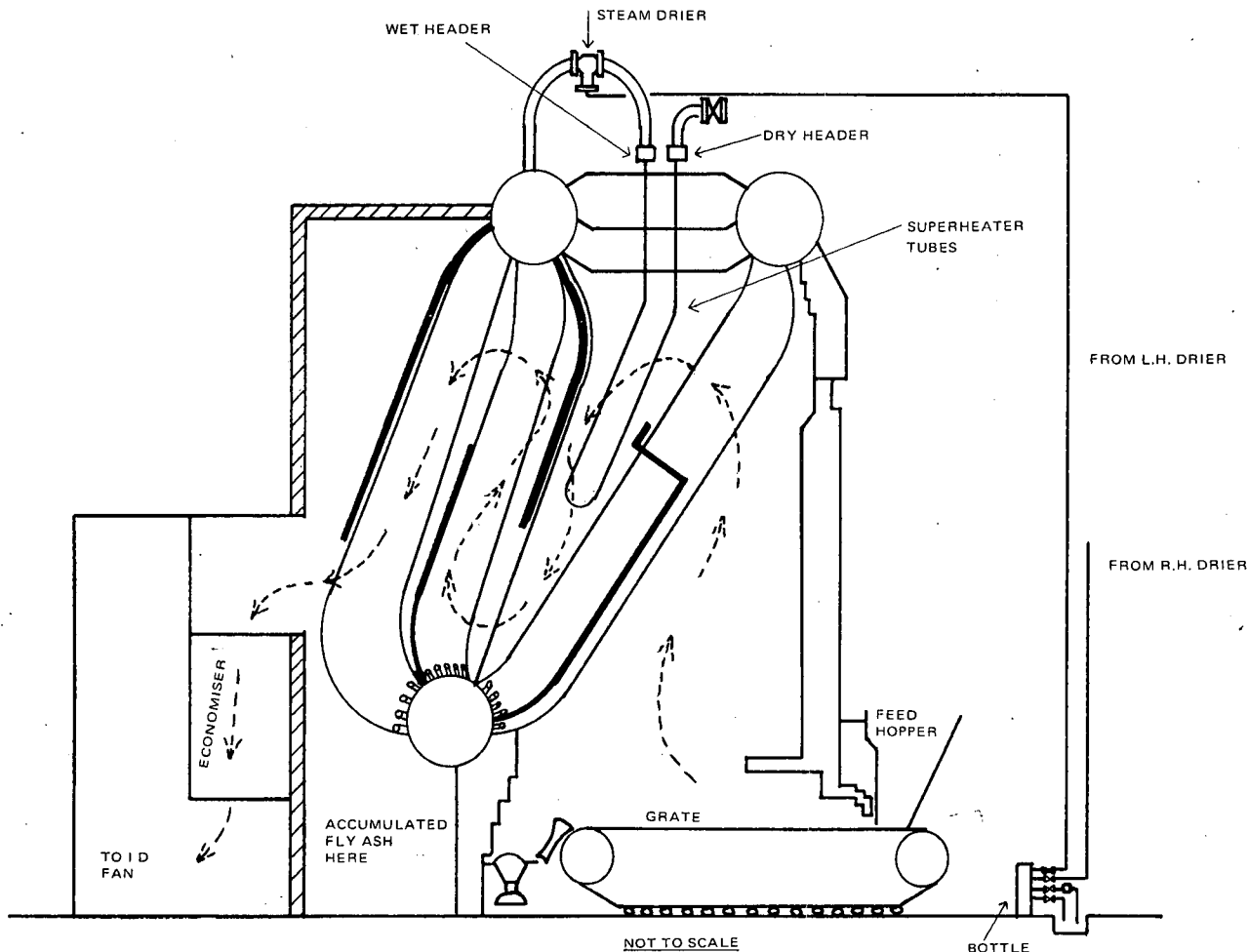


DIAGRAM NO. 5: Cross-sectional drawing of Stirling boiler,

to be satisfactory the other two were modified in the same manner.

Basically the principle is to change the flow of gases and to reduce the velocity of gases at the point of direction change. This has been achieved by increasing the cross sectional area after direction change. The heavy particles of flyash are thrown to the bottom of the collection box and the clean gases rise at a lower velocity and then pass through the economisers.

Instructions were given to the boiler staff to continue soot-blowing to the normal schedule but under no circumstances were the economisers to be water washed.

The inspection doors to the economisers were opened each weekend for an examination of the condition of the fins on the tubes and it was observed that they became covered with a light black soot which could virtually be brushed off with a feather duster, so lightly did it adhere to the fins.

After three months permission was given for the tubes to be washed on the shutdown weekend with a firehose and then dried out with compressed air before the boiler was put on range again on the Sunday night.

Photograph H shows the condition of the finned tubes when they had to be removed for thorough cleaning. As can be seen these tubes are choked to such an extent that the boiler could only steam with the by pass flues partly open — a severe waste of heat.

Photograph J shows the tubes after 12 months' steaming with flyash arresters fitted and without using water washing. Incidentally, the part of the tube showing partial choking is where there had been a leakage from above this area. This would appear to support the instructions regarding the abolition of water washing.

**TABLE 5**  
Fly Ash Analysis

The flyash which accumulates at the arresters had the following analysis:

Moisture	2.23%
Ash	17.06%
Volatile	14.57%
Fixed Carbon	68.37%
Cal Value	12870 BTU/lb.

The analysis confirms that the flyash is in fact coal dust which would be very difficult to use although it represents  $\frac{1}{4}$  of 1% or about 20 tons/month. In actual test it failed to ignite, burn or smoulder even when subjected to the flame of an acetylene torch. It reached the stage where it became red hot and glowed, but when the torch was removed it died down.

**TABLE 6**  
Fly Ash Grit Size

Grading of grits taken from arrester spout between boiler and economiser:

+6 mesh	Nil%
6-30 mesh	23.5%
30-72 mesh	53.8%
72-120 mesh	15.1%
120-230 mesh	5.5%
-230 mesh	2.1%

Flyash arresters have shown a substantial economy through obtaining a better heat transfer and greater thermal efficiency in the economiser resulting in a lower flue gas temperature in the stacks. A side effect of the flyash arresters is that the general cleanliness of the factory has improved, there is now not so much flyash on the roofs and in the gutters and rain water can now run away as it should. Also less time is spent on roof cleaning.

The amount of flyash removed from the spouts of the arresters is one quarter of one per cent. of the tonnage of coal burnt, about 20 tons/month.

An examination of the induced draught fan runner after twelve months' service showed very little erosion of the blades and virtually no build-up of dirt on the runner anywhere. These results are considered eminently satisfactory and an additional economy in operation.

### 5.00 The use of accumulators

This section is written in a lighter vein and deals with the psychological handling of persons, in this case boiler attendants.

A clash of personalities developed between our shift boiler attendants.

Standing instructions were that the accumulator had to be maintained at a pressure between a low of 90 p.s.i. and a high of 150 p.s.i. An explanation had to be given if the chart went beyond these limitations.

One boiler attendant resented being told by another boiler attendant that he could not handle the boilers correctly and set out to prove that he could control the accumulator pressure.

As will be seen from the accompanying accumulator chart the one shift maintained the accumulator pressure to a consistent 125 p.s.i. (Chart 7.)

Knowing and understanding the temperaments of the men under the control of the Engineer is absolutely essential if the best is to be obtained from those men.

When this accumulator chart was examined a query was naturally raised as to why this pressure was so consistent on one shift, whereas the other shifts showed a normal chart range. When the facts of the case were brought to light, no immediate action could be taken from a psychological aspect as this was something which had to be worked out of this boiler attendant's system.

A personal interest was taken in the respective boiler attendant and his controlling of the boilers was examined several times per shift each day in the boiler house and a sympathetic ear was turned to his troubles. He was given every encouragement. His duties became extremely onerous for he was continually altering the boiler outputs to suit the accumulator, sometimes at two minute intervals. At the end of his shift he was physically worn out due to his excessive running around controlling the boilers.

After three days he was congratulated on his achievement and told that since he now had proved his point he could settle back and control the boilers to the limitations of the accumulator chart lines.

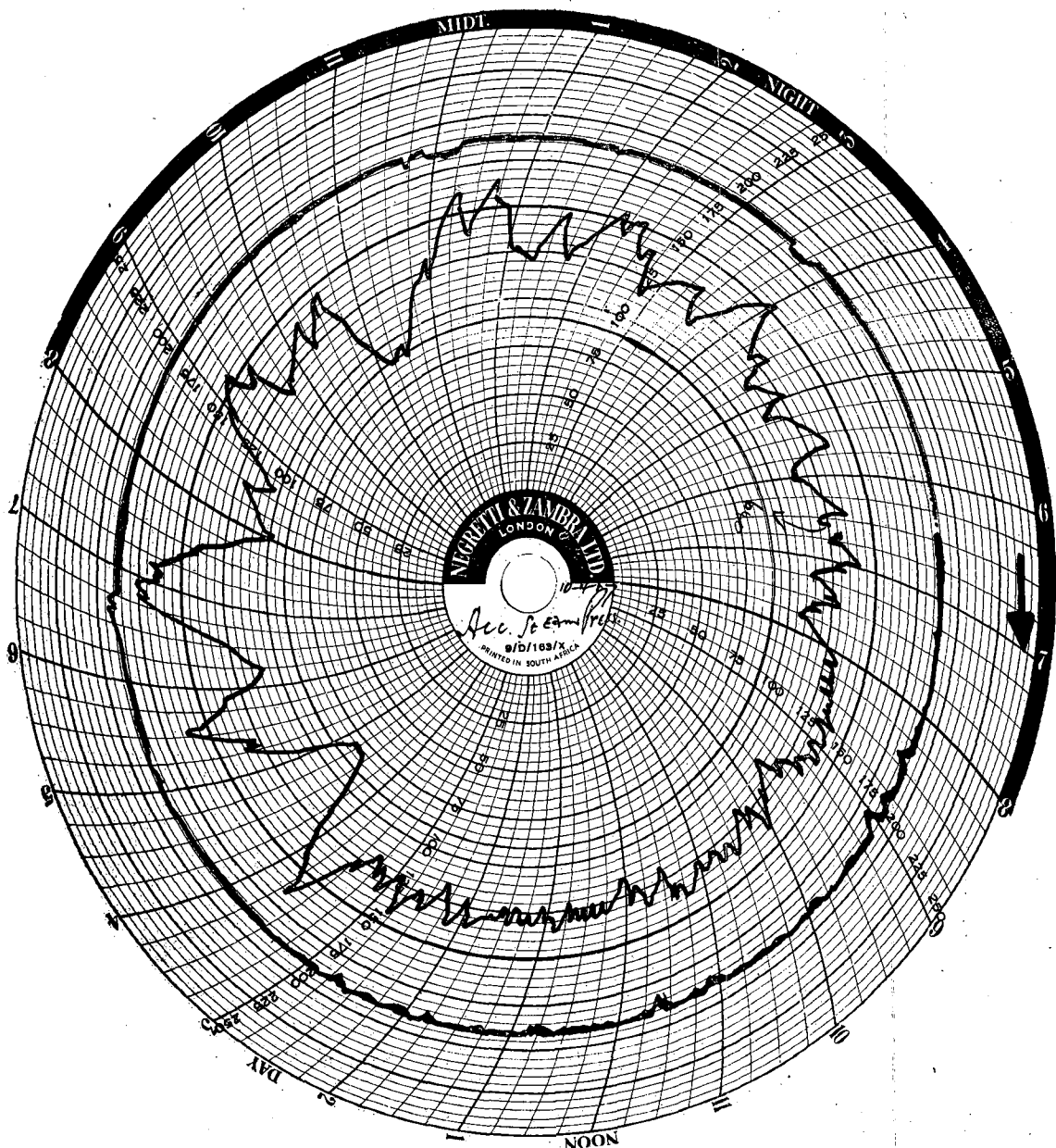


CHART 7

This he was only too willing to do and he fell back into normal control.

I shudder when the boiler charts of this period are examined for they show excessive variations in output on one shift, in other words they were doing the work of the accumulators and also the thermal efficiency of the plant fell during this period, but this was a small price to pay in order to maintain a happy, harmonious relationship between these boiler attendants, all of whom are good men.

**Acknowledgements**

Thanks are due to Natal Associated Collieries

(Pty) Limited and particularly to their Fuel Technologist, Mr. E. A. Cole, for their close co-operation and assistance in the tests on the additive described in Section 3.00 and for the photographs of clinker.

Thanks are also due to Messrs. Hulett's S.A. Refineries Limited for their permission to use the charts from boilers and accumulators and photographs of the economiser tubes.

**References**

James, W. G., A.M.Inst.F. and Fisher, A. H., A.M.Inst.F. A new fuel additive for coal-fired boilers. Journal of the Institute of Fuel. April, 1967, p. 170-172.



A: Deposit taken from generating tube showing heavy build-up causing chokeage through birdnesting. Chord dimension 4".



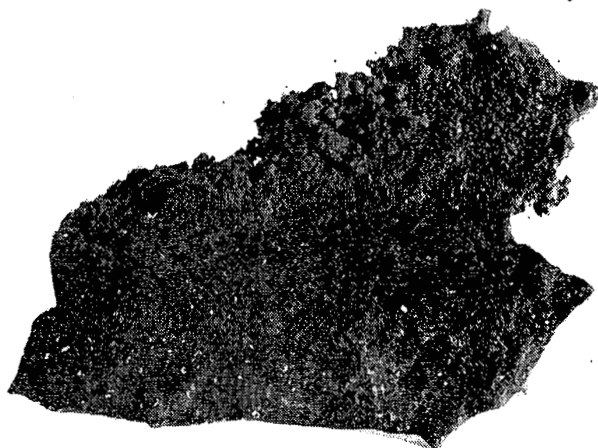
C. Clinker sample clearly showing the folds which formed at the finger bars while still in its plastic state. Sample 6" long.



D. Sample taken from 2nd tube on side water wall adjacent to ignition arch showing friable surface next to the tube and dense mass at rear of mass (fireside). Sample about 8" long.



B. Vitrified deposit taken from boiler arch brickwork. 3" maximum horizontal dimension (thickness).



E. Reverse view of photograph D showing dense mass of clinker attached to the tube as seen from the fireside.



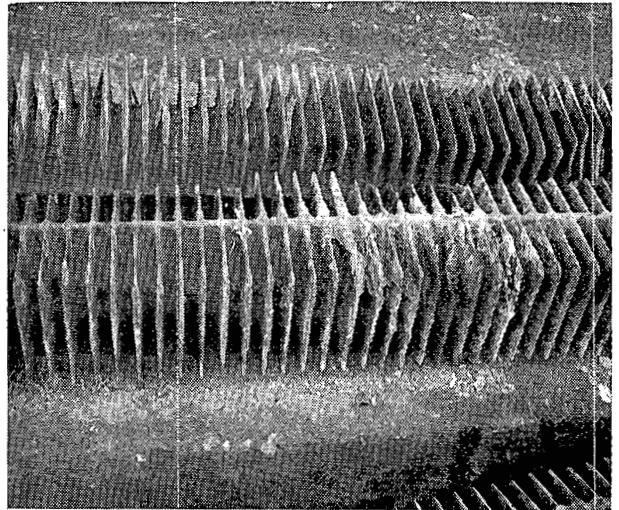
F. Deposit taken from side water wall tube showing dense but perforated deposit which has broken free from tube after being treated. Sample about 3 ft. long.



G. Sample from boiler being treated. The soft friable nature of the deposit can be clearly seen. Sample  $7\frac{1}{2}$ " long.



H. Economiser tubes choked with deposit. All tubes had to be removed from economiser and each one physically cleaned to bare metal. Boilers sootblown daily, economiser waterwashed every second day. Before flyash arresters fitted.



I. Economiser tube after 12 months' steaming with flyash arresters fitted. Normal sootblowing. No waterwashing. Note the effect of water on the tubes where slight build-up has occurred.

### Discussion

**Mr. Ashe:** What was the effect of the chemical additive on the clinker?

**Mr. Shum:** We used the additive because we had tube fouling and clinker trouble.

The effect of the additive on the clinker was to break it down into smaller portions, and on the tubes it softened the build-up and allowed it to be crumpled by hand.

**Mr. Hulett** (in the chair): It is possible that it was a change in the coal supply, not the additive, that caused the improvement.

**Mr. Shum:** I do not think so because when he stopped using Blitox we got a build-up on tubes and brickwork, and clinker trouble.

A small part of the fly ash is re-used in the proportions of 3 fly ash to 1 Blitox to give more bulk and make it more easily distributable when feeding onto the conveyor of coal supplying the boilers.

**Mr. Fokkens:** We use a very small amount of additive in our boilers with great success.

We sometimes have to fire the boilers with coal but we do not clean them during the year. There is no clinker and no birdnesting.

**Mr. Magasiner:** A very low pressure drop is reported across the superheater. Any superheater of this type is susceptible to overheating. By increasing the pressure drop by 10-15 lbs. the possibility of starving and hence overheating one of the loops is reduced. While the presence of scale cannot be condoned the more even steam distribution resulting from a higher pressure drop minimises its effect.

To improve steam purity, cyclones can be designed to fit into the drum.

I agree that unless coal is presented correctly to the boiler it will not be able to handle it.

I have had very little experience of chemical additives but that which I have had has been contrary to what is described in this paper. I am pleased to note that a measure of success has been achieved.

On an economiser three different types of gas side fouling can be expected. A phosphatic deposit at the high temperature end, a sulphatic deposit at the low temperature end and general fouling due to dust. Since the main fouling problem reported was due to dust by removing this the economiser was kept clean. Water washing appears to be the only way to remove phosphatic deposits. Sulphatic deposits are highly corrosive and unless high metal temperatures are maintained they will cause a lot

of damage. Cast iron economisers are better suited to withstand sulphatic deposit attack. If metal temperatures, however, can be kept above the dew point, mild steel economisers can be safely used without danger of corrosion.

As regards birdnesting, if the temperature of the gases leaving the combustion chamber can be reduced to about 500°F below the ash fusion temperature, this will largely be eliminated. To achieve this a fully water cooled combustion chamber of fairly large proportions must be incorporated in the design.

**Mr. Shum:** The steam drier referred to in the paper is not to improve the quality of the steam, but to cope with priming and/or foaming caused by contamination of the feed water by unwanted impurities such as sugar.

Plant layout and initial design determines the pressure drop across the superheater headers. Our factory has 220 psi boilers and the turbine was designed to run at 200 psi. We try to keep the pressure drop across the superheater headers as high as possible, but frictional and other normal resistances in the steam line limit the amount of pressure drop across the superheater headers since the maximum allowable pressure drop between the drums and the turbine is 20 psi by design, and consequently the pressure drop through the superheater tubes is only 1 or 2 psi.

As regards clinker build up, the boilers in use at the factory where I am now are having a clinker build-up despite the application of an additive which is not Blitox. However, I am giving it a longer trial before changing the additive to Blitox.

Water washing an economiser causes corrosion of the tubes and fins and this irregular surface permits dust and fly ash to adhere and cause a build-up and consequent choking of the tubes as can be seen—photograph 1. Our experience has been that, without water washing, the tubes have remained clean and the gas flow remains unimpeded.

It should be borne in mind that this paper deals only with the operation of existing plant and not with the initial design of the boilers.

**Mr. Magasiner:** I did not make myself clear about the superheater pressure drop.

The boiler drum should be designed for about 10 to 15 pounds higher pressure than one anticipates and this should be dropped across the superheater by using high velocity of steam through the superheater tubes.