INHERENT STEAM LOSSES FOUND IN WATER TUBE BOILERS

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It would be safe to estimate that over 90 per cent. of steam used in the Natal Sugar Mills, is generated, using bagasse fuel, by what are known as Water Tube Steam Raisers of the horizontal land and other types, and they possess peculiar features, which inherently interfere with the efficient production of steam.

The characteristics observed during steaming such kind of boilers on load reveal the following innate properties —

(1) Irregular water levels in the water glass columns. In the double drum horizontal land type, illustrated by Diagram 1, the water level of the left hand side drum is lower than that of the right side one. In regard to the Marine Cross Drum Type, *vide* Diagram 2, the water level in the drum is in reverse order to that of the horizontal double drum land class.

(2) The boiler carries a heavier deposit of scale in the right drum and its complement of circulating tubes, and in many cases the colour of the scale in the right side is different from the colour of the scale in the left side. This divides the unit into two distinct halves. In the case of the Marine Cross Type Boiler, the scale deposit increases gradually from about the middle row of headers to those on the left side.

(3) The boiler water under steam pressure possesses variable chemical properties.

(4) Furnace flames do not follow through the flue passes to the base of the stack, in a straight line.

(5) Soot deposits follow a similar course to that of the scale deposit.

(6) The extreme right hand unit of a battery of boilers of the same make and type is usually found to be a slower steamer than the left hand side units. The Marine Type Boilers acting reversely.

(7) Magnetic Fields surround all kinds of boilers of the water tube class. In regard to the loco types, which may be termed fire tube ones the earth's magnetic field exercises an influence, but not so in connection with the water tube steamers. Cases on record indicate reversals of magnetism when the flue gases change their direction of flow from flue pass to pass.

It is evident that all the aforegoing characteristics are governed by a force or combination of physical forces, which unknown to the designers entered into the construction of the boilers under review.

In order to get at the origin of the cause of this mysterious happening, 20 Boiler House Plants, comprising 109 of all kinds of steam boilers were surveyed over a period of about ten years, to wit:—

Fuel Used	System of Firing	No. of Boilers
Coal ...	Hand fired	8
	Chain grate stoker	27
	Mechanical push bar	9
Waste Heat	Natural draught ...	7
Bagasse ...	Semi-Cook furnace	37
	Step grate	12
Wattle Bark	Dutch Over hand-fired	7
Wood ...	Flat grate	2
	Total No. Boilers surveyed...	109

Diagrams 1 and 2 diagramatically indicate that the directions of flow of water circulation and the travel of the furnace flame move at right angles to each other, the main principle followed by designers when constructing this type of steam raiser. As will be appreciated later on this survey, following this principle unwittingly allows an error to creep in regard to steam generation, in spite of the apparent advantage which designers feel they are deriving when staggering the tubes coupled with the right angle flow of flue gases.

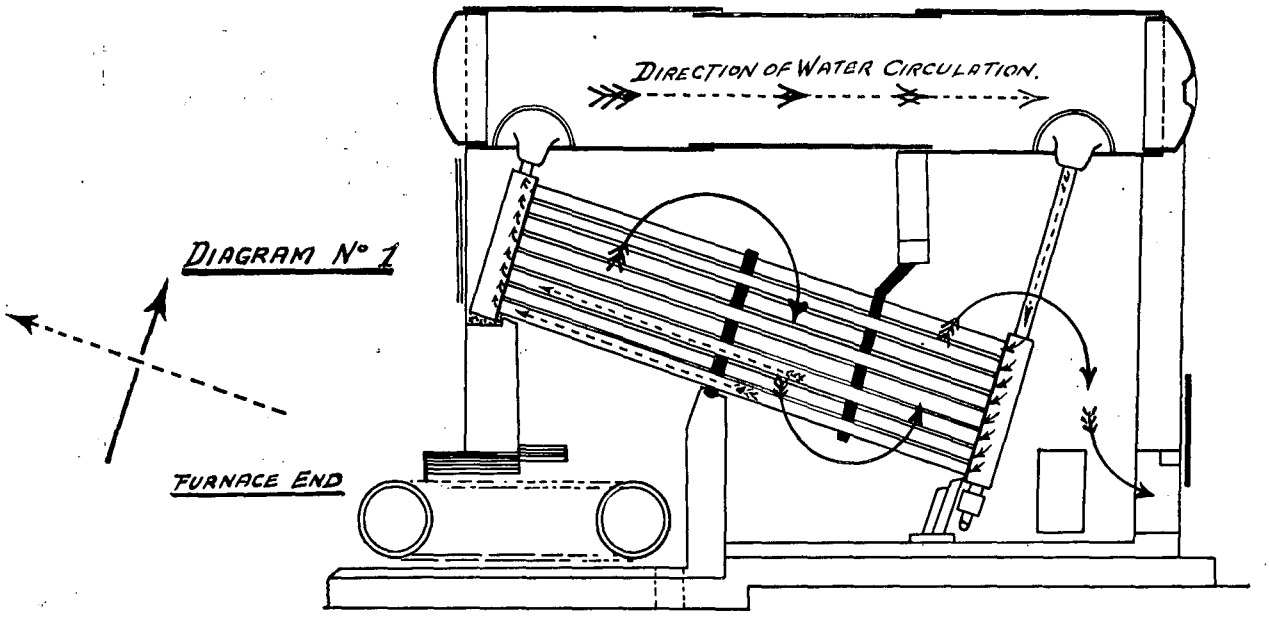
Looking at the two different designs of the boilers *vide* Diagrams 1 and 2, from the furnace front, it is evident, that the boiler water circulation is in opposite directions, which gives one the first clue to the cause of this mysterious irregular steaming property.

Chemical Differences of the Boiler Water when under Steam Pressure

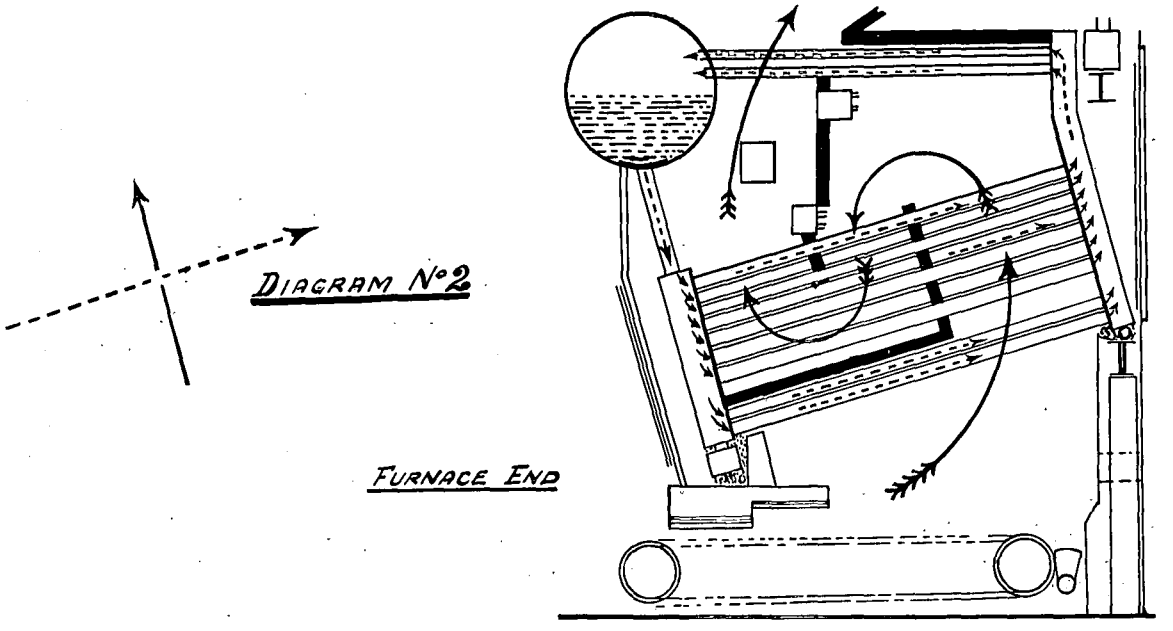
In connection with this phase of the survey, it was argued that the water properties inside the boiler would be uniform. According to popular belief it could not be otherwise.

In order to test the position, a boiler unit which had its middle pair of downcoming circulating tubes crossed over, was chosen because it was claimed that this crossing over of the two downcomers between the two drums would eliminate the irregular water levels.

MULTI-INCLINED WATER TUBE BOILER B & W LAND TYPE



MULTI-INCLINED WATER TUBE BOILER B & W MARINE TYPE



Result of the test: a representative one.

	Left Drum	*Right Drum*
Alkalinity to Phenolphthalein	2–9 c.cs. N/10 acid	4–8 c.cs. N/10 acid
Alkalinity to Methol Orange	7–0 c.cs. N/10 acid	12–25 c.cs. N/10 acid

This test surprised the party who conducted it.

It will be appreciated from this simple test, crossing over the downcoming circulating tubes between the drums only, has no effect upon the chemical differences of the water inside a water tube boiler.

Two Single Drum Boilers with a Common Brick Setting.

When single drum units having the same area of heating surface, one would normally expect the same strength of Alkalinity figures in each drum. Apparently placing them side by side in a common brick setting, produces a similar effect as is associated with double drum boilers, and this is shown in the following test.

Duration of test six weeks.

No. 1 Boiler the left hand one gave a total Alkalinity of 33.4.

No. 2 Boiler the right hand one gave a total Alkalinity of 51.8.

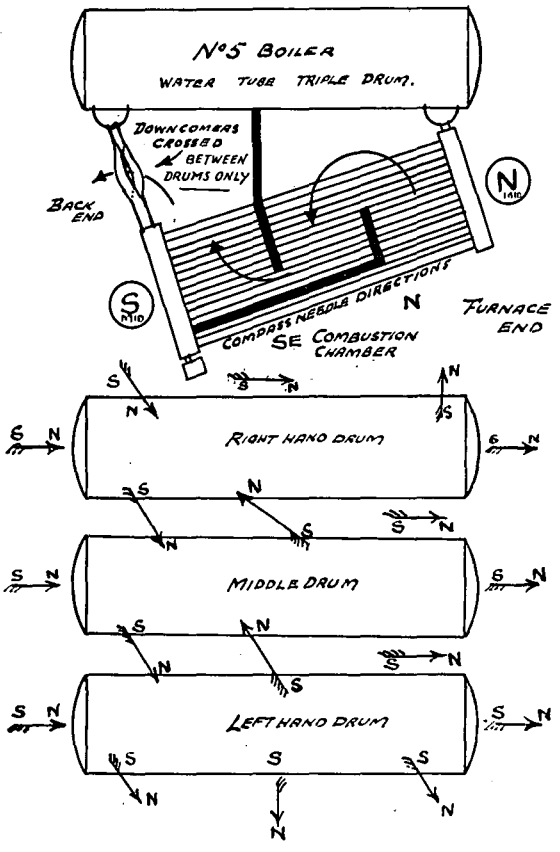
These figures speak for themselves, and it would appear that all the other characteristics mentioned and itemised earlier in this survey are dependent upon a physical force of some sort, either mechanical, electrical or chemical, severally or collectively.

Before proceeding further, it would be as well to quote Faraday's discovery, that electric currents are generated in conductors by moving them in a magnetic field and there is an electromotive force produced in the conductor, in a direction at right angles to the direction of motion, and at right angles also to the direction of the lines of force. Further consider the transverse movements of the sun, earth with its magnetism, they follow the principle as enunciated by Faraday. Similarly it is reasonable to assume that since it was found that Magnetism surrounded all kinds of water tube boilers, one was within one's right to use that famous British scientist's principle, on the grounds of heat and water circulation following a transverse movement, which in turn produced a magnetic effect stronger than that of a earth's field, and this can be verified in some boiler plants where it was found that the compass needle swung around 180 degrees when passing the instrument along the brick setting of the boiler.

Survey No. 10 illustrates this extraordinary finding.

SURVEY No. 10

MAGNETIC FIELD PLAN No. 3



Note—N.S. arrows actual directions of compass needle. The circled N. and S. are the true fields which would attract S. and N. seeking pole respectively. The field is apparently changed by the crossing over of down comers between drums. The principal point is that the furnace discloses a **N. field.**

Another convincing case is that of the right hand side of two separately independent fired boilers of the single drum land type in a common brick setting, which is generally known as a compound arrangement. In spite of this particular boiler with a much larger heating surface than its sister boiler, it would not deliver its full duty. On the face of it, it all sounds ridiculous. Every time the fires were cleaned, down would come the steam to a very low figure of 7,000 lbs. per hour as registered by the steam flow meter. Its rated capacity was 10,000 lbs. of steam per hour.

Eventually all the downcoming tubes of the circulating system were crossed over in pairs, *vide* Diagram 3.

The object in mind was to break up the uniform flow of the liquid flywheels as visualised and set up in the header construction. Similarly if the conductor in an armature were likewise treated no current would flow and the magnetism would to a certain extent exercise no influence. In other

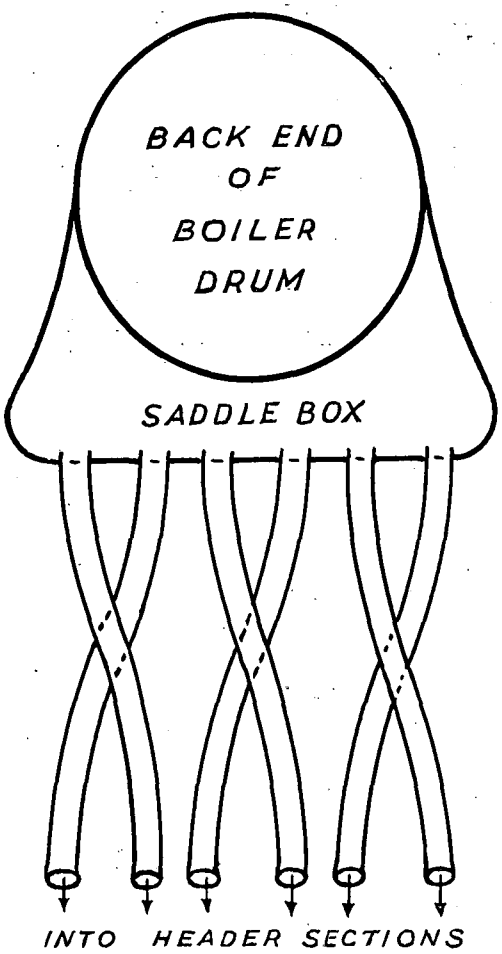


DIAGRAM 3

Depicting crossing over of down-comer tubes in order to demagnetise boiler.

words damp as much as possible of the magnetising effect of the two elements represented by the furnace flame and the circulating water, producing a thermal reaction in the steaming of the boiler while under load producing better results.

The result of this practical test or trial was astounding. The boiler delivered up to as much as 13,000 lbs. of steam as measured by the Steam Flow Meter. The European firemen expressed themselves as feeling satisfied, most of their troubles were solved.

The following figures obtained under practical operating conditions confirm the previous trial of the survey.

A double drum boiler of the horizontal land type was selected, because of its right hand position in the range, therefore being a lazy steamer.

Remarks in connection with the following test, from the Engineer:

"There were no alterations to the furnace. I think the figures would have been better had we not had the misfortune of a steam coil parting in one of the Vacuum Pans, and not being spotted in time to prevent the sugar finding its way into the feed water.

Monthly Results		Evaporation (lbs. per hour H.S.)	Per Cent. Increase
August	1938 ...	3.4	Tubes not crossed
	1939 ...	3.46	Tubes crossed 1.8
	1940 ...	3.70	Tubes crossed 8.9
September	1938 ...	3.25	Tubes not crossed
	1939 ...	3.58	Tubes crossed 8.6
	1940 ...	3.70	Tubes crossed 13.8
October	1938 ...	3.14	Tubes not crossed
	1939 ...	3.42	Tubes crossed 8.9
	1940 ...	3.70	Tubes crossed 17.8
November	1938 ...	3.41	Tubes not crossed
	1939 ...	3.44	Tubes crossed .88
	1940 ...	3.65	Tubes crossed 7.0

On opening up the boilers this off-season we found the steam scrubber or separator in the boiler drums half choked with sugar carbon which naturally retarded the steam discharger. We were not short of steam so did not open the boiler during the crop of 1939."

Obviously the figures speak for themselves and it should be clear at this stage that a great saving of steam is possible in the Sugar Industry. The 1940 figures give an overall average saving of 11.9 per cent. which is a very profitable return on a comparatively small outlay of money.

Therefore this practical test is of great value and serves to show that it is possible to rectify the irregularities in a simple manner without having to invest money in contrivances which usually add to the worries of a maintenance engineer.

It is interesting to record that by crossing over all the tubes in pairs, no undue stresses were revealed when the boilers were opened up for a check inspection.

Possible Savings in the Sugar Industry

The average amount of Bagasse available during the two previous years was approximately 1,890,000 tons.

Assuming a L.C.V. of Bagasse at 3,136 B.T.Us./LB. and a Boiler efficiency of say 70 per cent. which is low, together with only a saving of 10 per cent. of steam by crossing all the down-comers of Water Tube Boilers in the Industry, it will be found that an overall saving of about 600,000 lbs. of Steam per hour can be expected. Correlate this saving with the amount of Sugar produced, an expected saving of £1 per ton is assured, on the basis of reckoning of £1 per lb. of steam evaported when purchasing boilers to evaporate this amount of steam saved.

Likewise an extra 189,000 tons of bagasse could be accumulated for the making of paper or paper products.

Mr. Farquharson said he would hesitate to cross swords with Mr. Lindemann regarding boilers or their operation but he had to agree with remarks made regarding the shielded magnetic circuit. There was also a further point. Mr. Lindemann had stated: "Similarly if the conductors in an armature were likewise treated" (i.e. crossed) "no current would flow and the magnetism would to a certain extent exercise no influence." This was not the case. Crossing the conductors did not alter the direction in which they cut the lines of force, therefore the electromotive force would be the same as before. As a matter of fact, armatures had been manufactured with conductors twisted in the slots and they worked very well, but mechanical difficulties prevented this arrangement becoming popular. The reason for this type of winding was to improve efficiency by minimising the interaction between conductors and reducing circulating currents in the conductors themselves.

Mr. McCulloch said he wished to congratulate Mr. Lindemann on his paper which contained some novel explanations of peculiar boiler characteristics. It seemed to him that it would be possible to account for the magnetic fields associated with boilers by the elctrical currents which would be generated by thermal E.M.F.'s caused by temperature differences across different parts of the boiler structure. The thermal electrical effect was a well known phenomenon and occurred when there was a temperature gradient across two metals or metallic parts in contact. Although the magnitude of the individual E.M.F.'s was small, the associated current could be of appreciable magnitude owing to the large mass of metal and the relatively low ohmic resistance of the path through which it circulated.

The improvement in the boiler performance due to transposing the downcomer tubes seemed remarkable, but he was doubtful if the explanation was wholly due to this change. Boiler evaporation was substantially affected by scaled and dirty tube surfaces and he considered that part of the improvement mentioned was due to the installation of new tubes.

Mr. Gunn submitted that Mr. Lindemann had delivered a very excellent paper which should give rise to much discussion. He noted that Mr. Lindemann stated that it was always the left hand boiler of the range which did the most steaming. He also stated that boiler water under steam pressure possessed variable chemical properties. One would accept this second statement and one would be reasonably correct to assume that with boilers on the same range the pressures would be equal and therefore the effect of pressure on all the boilers on range would be similar. Mr. Lindemann somewhat contradicted the first statement by saying that after six weeks testing, the alkalinity of the right hand boiler was higher than that of the left. That would indicate to him that the concentration of the boiler water had increased and that could only be caused by increased evaporation. In other words, it indicated that the right hand boiler had been working harder than the left. He asked whether the example quoted was an exception to his rule.

Dr. Douwes Dekker said that the data given at the top of p. 4 of Mr. Lindemann's paper indicated a greater evaporation when the tubes were crossed. In his conclusions, however, Mr. Lindemann assumed a better boiler efficiency, which was not the same. Were data available which showed that the better evaporation was not due to more fuel being burned?

Dr. Parrish said it was difficult to see how any magnetic force could operate within a boiler, since the inside of a boiler would be magnetically shielded. If, however, it was assumed that magnetism was produced within the boiler by the transverse movement of gas and water, what possible effect could this magnetism have on the chemical properties of the boiler water?

Mr. Reynolds said that careful tests carried out by the makers of the boilers to which he referred had revealed no increase in steam raising ability due to the provision of a multiplicity of cross-over downtake tubes. He explained that the crossed tubes were originally developed for the purpose of equalising the water levels in the drums of multiple drum boilers, in which capacity they served their purpose reasonably well.

Mr. Dymond asked that a hearty vote of thanks be given to Mr. Lindemann.