

REDUCTION OF ENTRAINMENT FROM VACUUM PANS AND EVAPORATORS

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Summary

Methods of eliminating entrainment from vacuum pans and evaporators are described and the maintenance of steady vacuum and steam pressure to ensure ideal conditions for good performance of vacuum pans and evaporators, is discussed. Methods used at Umfolozi are described.

Introduction

One of the main contributors to undetermined losses is entrainment from vacuum pans and evaporators.

Large sums of money are spent on the installation of "savealls" of various shapes and sizes, in order to recover some of the highly concentrated syrup carried away with the vapours.

Some of the installations are fairly efficient but some do not work at all. Samples collected from points between "savealls" and the barometric condensers shows that not all the syrup entrained has been trapped and, therefore, even with "savealls", losses still occur.

What is the answer?

"Prevention is better than cure" — therefore, let us try and prevent entrainment rather than spend a lot of money trying to cure it.

Services required for the operation of a pan are:

- (a) Steam to calandria
- (b) Vacuum
- (c) Water to condenser
- (d) Syrup or molasses.

Pressure fluctuations in (a) and (c) are beyond the control of the pan boiler but can cause detrimental effects to his work by changing the boiling rate either by change in steam flow or change in vacuum.

It is often said, at Umfolozi also, that certain pans entrain more than others. On examination it will usually be found that it is caused by one of the outside services to the pan, which are listed above.

Steam pressure

The pan station at Umfolozi consists of 10 pans of various sizes, makes and design. They are arranged in pairs down the building as shown in Figure 1.

Some years ago, exhaust steam at 0,4 bar was supplied to the pans via a 610 mm diameter pipe, which ran down the one side of the pan floor and terminated at one end of the building. This is shown dotted in Figure 1.

The pans at the end of the line were notorious

for entrainment. It was found that in order to get enough steam to the calandrias of these pans the inlet steam valves were usually wide open. This worked until one or more pans somewhere else on the range were shut down, then the pressure would build up in the range and the pan on the end would suddenly get a boost of steam and start boiling profusely until the steam valve was closed to bring it under control again. During this period the pan would entrain heavily. The increase in temperature during this period was also undesirable.

The above used to happen in varying degrees on all the other pans.

Remedy

In order to overcome this problem it was decided, during one off-crop, to install a steam ring main around the pan floor and supply it with steam from more than one source. This is shown in Figure 1. In addition, an automatic pressure control valve was fitted into the range to keep the steam pressure constant at 0,4 bar. This controller opened a valve to atmosphere whenever the pressure exceeded 0,4 bar. When the pressure dropped below 0,4 bar, steam from the steam accumulators was fed automatically into the range to maintain it at 0,4 bar.

A typical steam pressure chart from the pan floor steam range is shown in Figure 2.

This has eliminated the problem of erratic steam supply to the pans.

Vacuum

The next outside service supplied to the pan floor is vacuum. Erratic vacuum on a pan causes upsets in the boiling similar to erratic steam pressure described above, with the same consequences, namely, entrainment.

As in the case of the steam, all pans were connected to a common vacuum line. This meant that all pans boiled at the same vacuum and temperature irrespective of the type of massecuite being boiled.

Remedy

Over a period of a few seasons, pans were separated from the common range by installing rotary vacuum pumps on four of the pans. Three other pans were fitted with water jet extractors and three remained on a common line to a reciprocating vacuum pump. A rotary vacuum pump is used on this line to help raise vacuum in a pan before it is opened on to the range and this avoids upsetting the vacuum on the other two pans.

A vacuum recorder was also fitted to this range and is visible to the pan boiler so that he is able

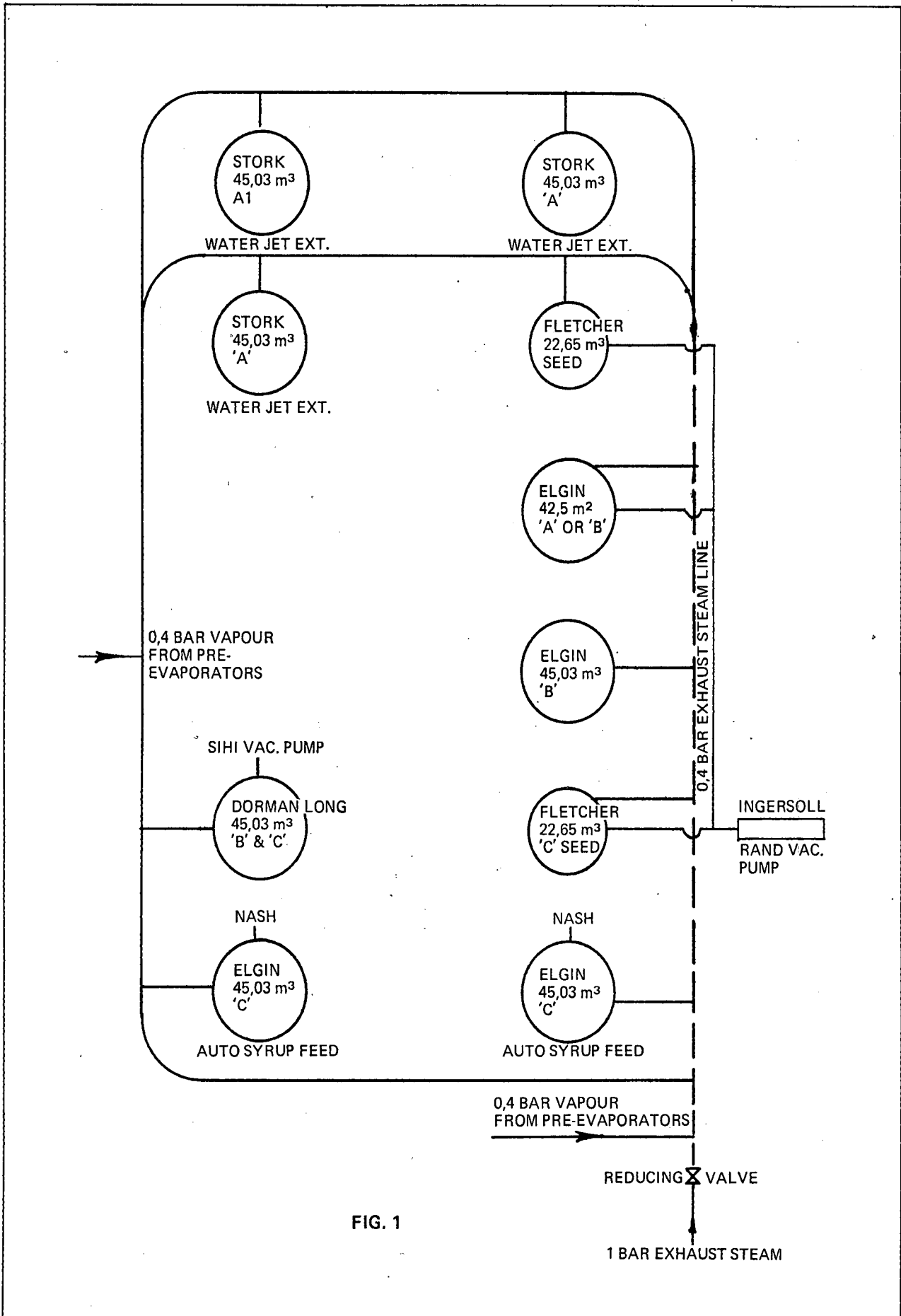


FIG. 1

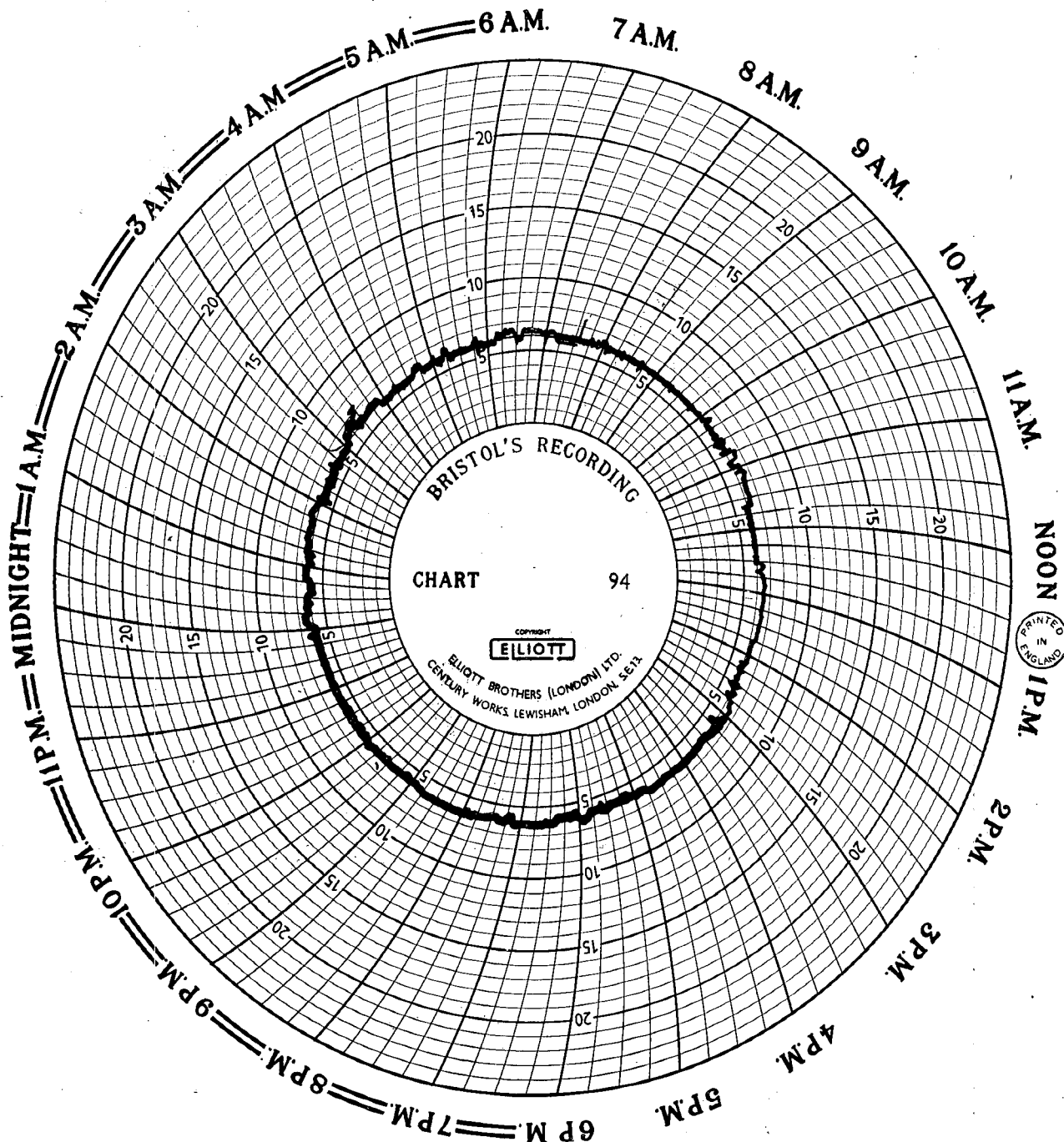


FIG. 2

to observe the chart when he is putting a pan on the range. If this is done carefully by opening the valves slowly, no drop in vacuum will occur, but if he is hasty there will be a drop in vacuum, as shown at 5 a.m. on the chart in Figure 3. The rest of the chart shows perfect vacuum.

Vacuum control on fourth vessel of quad evaporator

In order to obtain steady vacuum in the evaporator, a vacuum controller was fitted to the last vessel of the quad.

The vacuum was monitored in the top of the vapour belt of the fourth vessel and the controller operated a butterfly valve fitted in the water line to the barometric condenser. The results are shown

on a typical chart in Figure 4. An added advantage of this type of controller is that only the exact amount of water required to maintain vacuum is used, and, therefore, the pumping load is reduced and there is a saving in horsepower.

Both evaporators are fitted with this type of controller and this off-crop one is being installed on a vacuum pan boiling A massecurtes.

Water to condensers

The third outside service to the pan floor is the water supply to the condensers.

How does this affect entrainment? In exactly the same way as irregular steam pressure.

The condensers are all fed from a common water

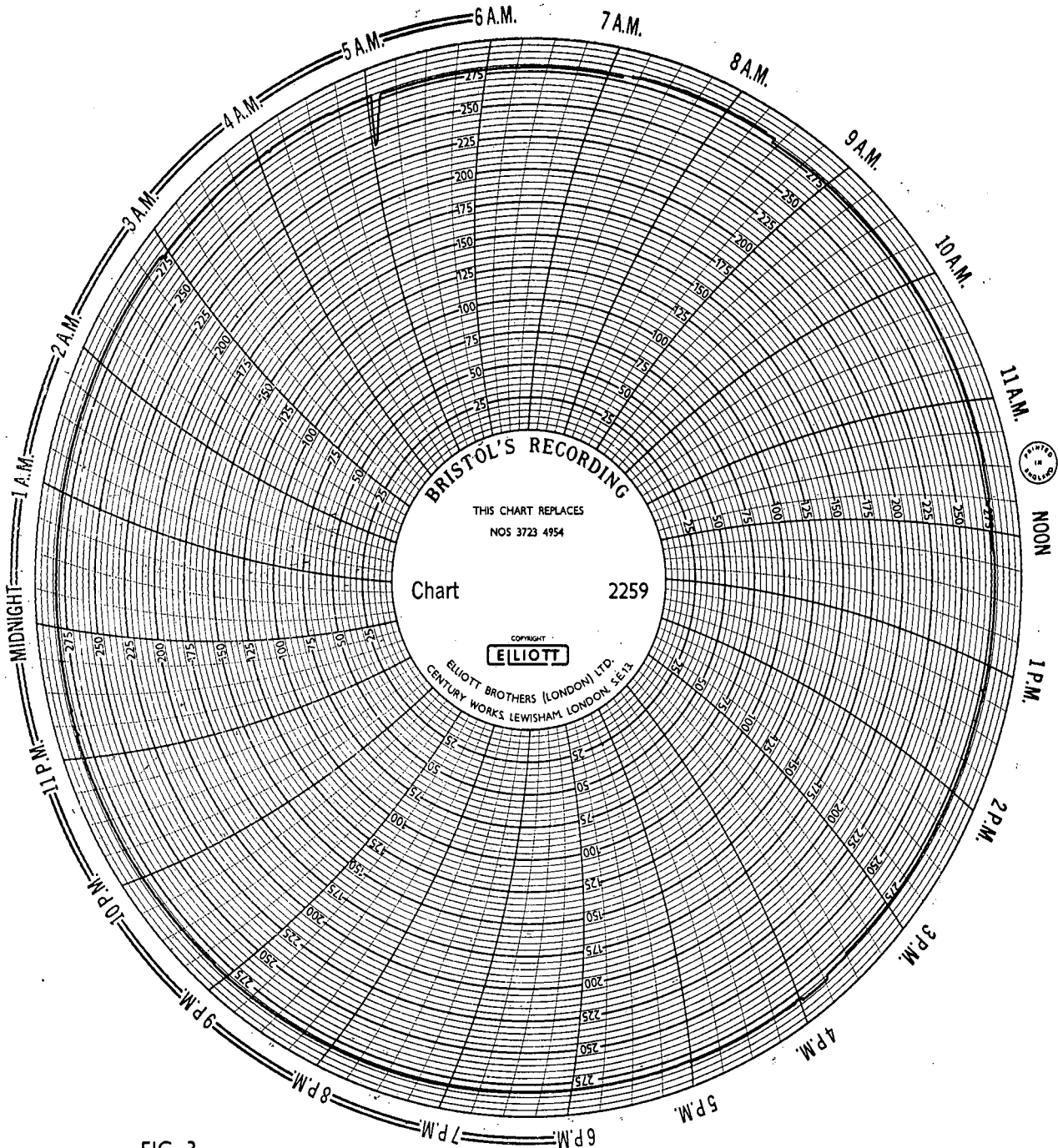


FIG. 3

manifold. When a pan is taken off line and the water valve is shut there is a pressure build-up in the manifold, and all other condensers open to the manifold at the time will obtain more water because of the increase in pressure. This will upset the vacuum in these pans and also the boiling, and consequently, entrainment will occur.

Remedy

The pump house, containing a number of large pumps, is situated next to the cooling pond.

The pumps feed into a common manifold which leads off to the pan condensers.

An automatic control valve was fitted to the manifold and was set to open at a pre-determined pressure allowing water to by-pass back to the cooling

pond and maintain a pressure of 0,5 bar in the manifold on the condensers at all times. Valves to the condensers and could now be opened and closed without affecting any other pan.

An added feature of this installation is that it has stopped the overflowing of the sealing wells which used to occur from time to time due to the sudden opening of water valves.

Syrup feed

Two 45 cubic metre vacuum pans used to boil C massecuite were fitted with automatic syrup or molasses feed valves.

This has helped to keep the pan boiling operation under control and has reduced the possibilities of entrainment.

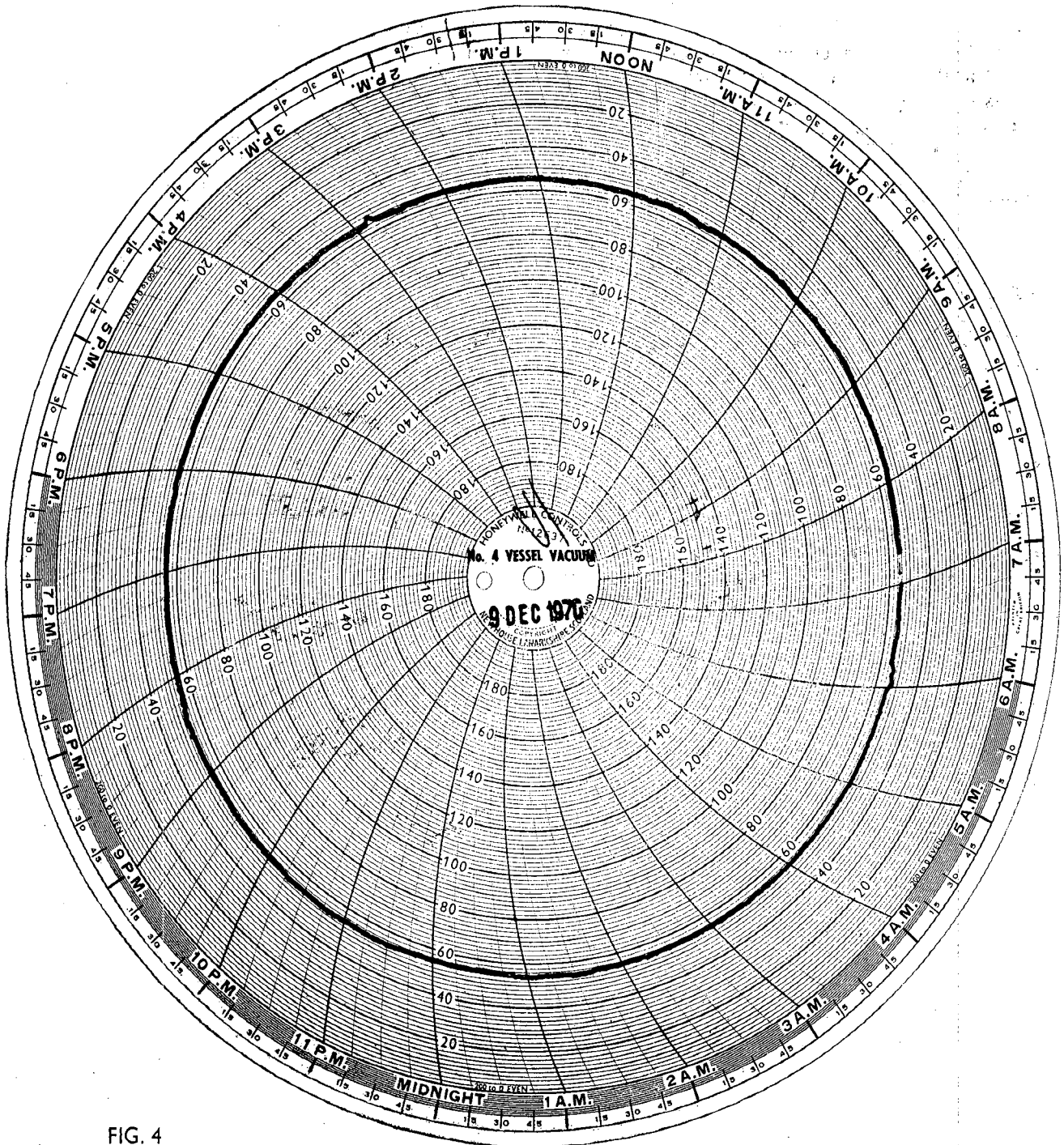


FIG. 4

Two brass electrodes are fitted to the side of the pan and connected to a cuitemeter which measures the conductivity of the massecuite, and as this varies for different densities of massecuite, it is possible to control the brix of the massecuite right through the boiling cycle.

The cuitemeter sends an electrical signal to an electro/pneumatic transducer which in turn operates an air operated valve which opens the required amount to keep the brix at the set point on the controller.

The pan boiler merely alters the set point from time to time until the pan has reached the required brix. A visual record of what is taking place is recorded on a strip chart in the cuitemeter.

This off-season two pans will be fitted with this type of controller.

Checking

Tell-tale pipes are fitted to all pans and evaporators and these are collected at regular intervals by the laboratory staff.

Although not completely eliminated, entrainment has been greatly reduced.

Conclusions

Before condemning a pan because it entrains, first study the outside services.

There are other causes of entrainment which have not been discussed, such as power failures, etc., and in some cases badly designed pans are the cause.

Umfolozi was forced to switch to untrained Bantu pan boilers during one season and without the above mentioned controls it would have been an impossible task.

Discussion

Mr. Cox: In a paper by Serbia and Balso presented at the 12th Congress in Puerto Rico in 1965 it was described how to measure entrainment in an evaporator by measuring conductivity.

They modified the operation of the evaporator by installing screens. They found a positive correlation between conductivity and the introduction of the screens.

There is no direct chemical correlation between the conductivity and the entrained sugar but for any installation there is an empirical correlation. It is therefore possible to put a conductivity meter, connected by a recording chart, at the tailpipe to give a continuous record of fluctuations in conductivity and therefore fluctuations in entrainment which have taken place.

Mr. Ashe: We considered this some years ago but so much water is used in the condensers that we did not think the amount of entrainment present would be detected by this method.

Mr. Rault: Were the changes made at Umfolozi reflected in the undetermined loss figure?

Mr. Ashe: Elimination of entrainment, plus the good housekeeping mentioned in my earlier paper, did contribute to a decrease in undetermined losses.

Dr. Matic: Conductivity is not the best way to measure entrainment owing to the presence of ammonia in entrained water.

The S.M.R.I. has ordered an instrument for measuring potassium content of the condensate.

Mr. Ashe: I understand that ammonia is more of a problem in the beet sugar industry.

Mr. Bruijn: Two years ago the S.M.R.I. at Mount Edgcombe investigated the condensates of the evaporators and pans. The conductivity method gave positive signals though analysis of the samples showed that no sugar was present. However ammonia was present and we found that samples of distilled water with ammonia gave the same conductivity as sucrose.

In Holland and Germany a flame photometry method is used which continuously monitors the potassium content. To determine 10 ppm sucrose in a condensate you can detect .1 ppm potassium.

Mr. Jullienne: Is there automatic control of water going into the condensers at Umfolozi?

Mr. Ashe: Yes, the evaporators are all automatically controlled and three of the vacuum pans have automatic control of water going to the condensers. An operator controls the supply manually on these pans and is guided by a vacuum chart.

Mr. van Hengel: When I was at the S.M.R.I. in 1964 Melville was continuously sampling water and analysing it every hour but sugar was never found in it. When a quarter of a drum of syrup was mixed with water and analysed the sucrose was clearly detected, indicating that the method being used was quite sound. I think that any substantial amounts of sugar should be detectable and I agree with the methods used at Umfolozi.