AUTOMATION IN THE SUGAR INDUSTRY

By RON HARDY

Three things are the essentials of the modern age. Instruments, to measure with the utmost accuracy what is going on; Electronics, to magnify those indications—be they sound, movement or anything else—thousands of times, and at the speed of light; Automatic control, to feed back that information into the machine, and give it, for the first time, the "feel" of the work it is doing and the power, when necessary, to correct is own mistakes.

From the way people talk and write, you might think that all this is something for the distant future. It is *not*—it is here now. You remember the man who spent all his life talking prose without knowing it. Well, we are, all of us, already living in the age of automation—though most of us still have to wake up to the fact. You see that not only in the quantity and low price of many of the things we buy every day of our lives—and of course only mass-production makes them possible. You see it also, though few people yet realise it, in the quality that we have all come to expect.

And where is all this going to take us next ? Do not for a moment believe—as some people would like to tell you—that automation means the death of the artist and craftsman. Just the reverse—it is one of the biggest opportunities they have ever had. The machine cannot design or think. You still have to have the designer and the craftsman to decide what you are going to make, and to design it. Then you put the fruits of their skill and brains into the punched card that controls it. But when you have done that, the artist's work can go to the millions instead of to the few.

Again, do not be misled into thinking that automation is going to mean a mass of redundancy and unemployment. I am sure that the ordinary man in the factory does not believe that, anyway. I have spent much of my life in factories where we were installing instrumentation and automatic control for the first time. Sometimes we have come across opposition—but it has usually been from the older technicians who do not welcome changes in the traditional way of doing things. Never in my own experience have I come across those cases where the worker is supposed to say: "This is going to do me out of a job."

A modern operator of an automatically-operated fire plant, for example, has to appreciate the significance of various kinds of meter, the results of flue analysis and other concepts far beyond "the brute force and ignorance" condition of his predecessors. In fact a comparison between the grimy caveman of the 1920's and the white boiler-suited worker in front of an instrument panel is an illuminating illustration of the effects of automation—educational, social and economic. It is unlikely that the type of skill required by these workers can ever remain static, for improved devices will constantly appear which will call for more education and training. And there must be a willingness to learn the new tricks and to accept the fact that changing conditions are a normal part of industrial life.

I would like to give here two examples of control which have been introduced into the Sugar Industry. The first is the pan vacuum control which will shortly be commissioned at Hulett's Refinery at Rossburgh.

Pan Vacuum Control

Object of Controls

During the boiling cycle the vacuum in the pans must be controlled within close limits, control being effected by regulating the water flowing into the jet condenser or through the process water heater.

Method

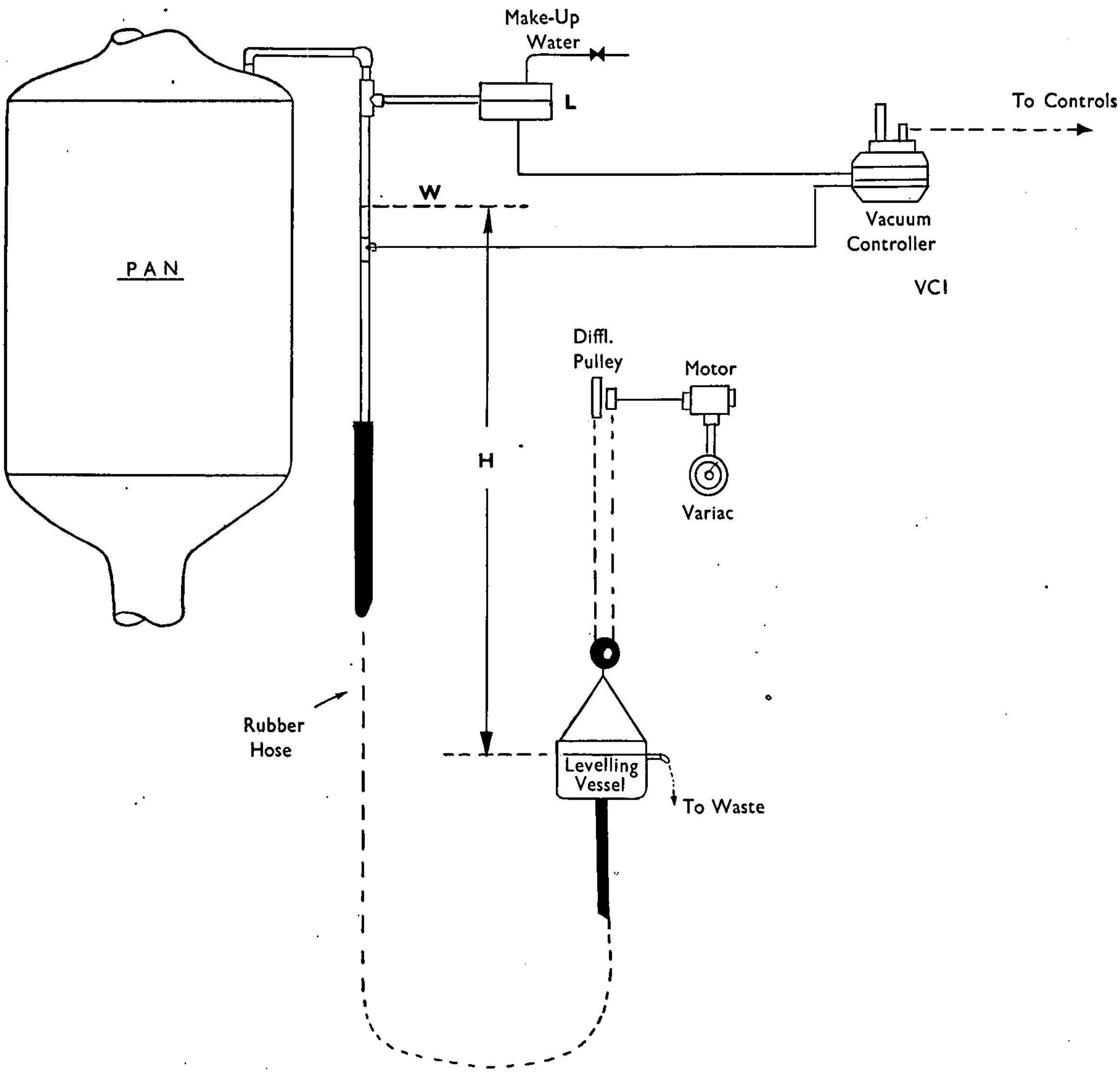
First of all we would refer you to the "Layout of Plant" sketch which shows the general arrangement of the levelling vessel.

This consists of a bucket which can be raised or lowered by means of a differential pulley block fitted to a motor-driven shaft. The bottom of the bucket is connected by rubber hose to a vertical impulse pipe coming from the top of the pan.

It will be seen that the negative head of water H in the vertical impulse line is a measure of the vacuum in the pan. Furthermore, for a given vacuum the level W may be raised or lowered by corresponding movement of the levelling vessel.

A tapping is taken from this vertical impulse line in the vacuum controller. Another tapping is brought in from a closed tank L, in which the level of water is maintained constant. The water head in this tank serves as a reference for the controller and a means of 'topping-up' the 'U' tube through a connection at the top of the impulse pipe.

It follows that the vacuum controller is measuring the difference in level between the tank L and level W in the impulse line and that the range of the controller is therefore small in comparison with the range of vacuum to be controlled. In other words, the controller is measuring only the upper portion of the negative column H and therefore allows a very sensitive control.



ARRANGEMENT OF LEVELLING VESSEL.

PAN VACUUM CONTROL

Fig. 1

The controller would be arranged to send out a pneumatic signal of 10-50 p.s.i.g., and a 30 p.s.i.g. signal would correspond to the level W being in the mid-point of the two tappings. Thus, if the level falls below the l.p. tapping, indicating that the vacuum is too low, then the controller would put out a 50 p.s.i.g. signal calling for more water to enter the condensers. As the vacuum increases and the level rises to the set point, the controller would reach a state of balance and drop the output signal to 30 p.s.i.g. again.

Conversely, if the level rises above the set point, indicating a high vacuum, then the controller would send out a lower signal causing a reduction in water flow to the condensers.

Thus, by adjusting the height of the levelling vessel until H corresponds in inches w.g. to the desired vacuum, that value may be controlled within very fine limits.

It remains now to describe the controls proper and we would refer to Fig. 2.

The pneumatic signal, sent out by the Vacuum Controller, VC1 goes to TR1 and A chamber of TR2. This signal also passes through a needle valve to B chamber of TR2 which introduces an integral action into the Control signal, which is them passed to Servomotor SM1.

The output signal from TR1 is fed into A chamber of TR3. The output signal from VC1 is fed into C chamber of TR3 also through the needle valve, into B chamber of TR3 which introduces an integral action into the Control signal which is then passed to SM2.

Now TR2 uses the 10–30 p.s.i.g. portion of output from RT whilst TR1 only uses the 30–50 p.s.i.g. portion. The reason for this is as follows:

There are two methods of controlling the vacuum in this instance, one by means of regulating the water flowing through the tubular heater and the other by regulating the water going into the barometric condenser. In the first case the heat taken from the condensing vapour is utilised for process heating, whereas in the second case the jet water condensing the vapour goes to waste.

It is desirable, therefore, to take up as much heat as is possible in the tubular heater. Thus the 10–30 p.s.i.g. portion of the signal is used for controlling the process water bypass valve V2, and if the desired vacuum is higher than can be maintained by the heater, then the barometric condenser comes into operation.

The signal from VC1 is also taken directly to the transforming relays in order to introduce derivative action into the system.

Facility for remote manual control is provided in relays R1 and R2.

Constant Density Milk of Lime

The second example is the control of density applicable to the Sugar Industry. This instrument was first introduced to the Sugar Industry and originally designed for the measuring of density of lime slurry, and is now finding widespread application because of its several unique features; and it can be used as a brix controller. The meter consists essentially of a loop of pipe carrying the flowing fluid, which is flexibly connected to the main and weighed continuously on a pneumatic force balance. It follows that any liquid or slurry that can be piped may also be metered, subject only to the limitations of the flexible connections. In the case of a slurry it is only necessary to maintain a velocity such that the deposition of solids is precluded and the meter readings will include the weight of solid particles too large to be detected by other types of instrument. Variations of velocity within wide limits have no effect on the meter.

Apart from the ability to handle slurries, the meter is characterised by the simplicity of its construction and calibration and the fact that no air interface with the liquid is necessary.

It was decided to make the process continuous rather than to produce batches of the correct density because no more plant is needed, and the labour of starting and stopping flows is avoided, with its attendant risks of blockages.

The essentials of the continuous system adopted are, in order of flow, a control valve to add diluting liquid to the main lime flow, a means of mixing, a continuous density meter, and a controller to adjust the valve in accordance with the difference between lime density as measured and its desired value.

First-rate control depends primarily upon a reliable and sensitive meter and a short time-lag of measurement. Trials have been conducted with several standard differential pressure instruments, in conjunction with bubbling tubes, stand pipes and purges of various designs, but none was thought suitable for purposes of automatic control application in the factory. The instruments were all good, but owing to the high temperature of the milk-of-lime and its content of sugar and fine sand a lot of attention was called for on the system in contact with the liquid. Furthermore, such density meters have a limited speed of flow and corresponding measurement lag; if installed in an open tank a minimum level and adequate stirring must be assured. One instrument maker responded to the need for a meter which would measure the density of a slurry and designed a system consisting basically of a loop of pipe flexibly jointed and supported by a pneumatic force balance. This came up to all requirements, and delivered its output signal in the form of an air pressure in the usual 3–15 p.s.i. instrument range.

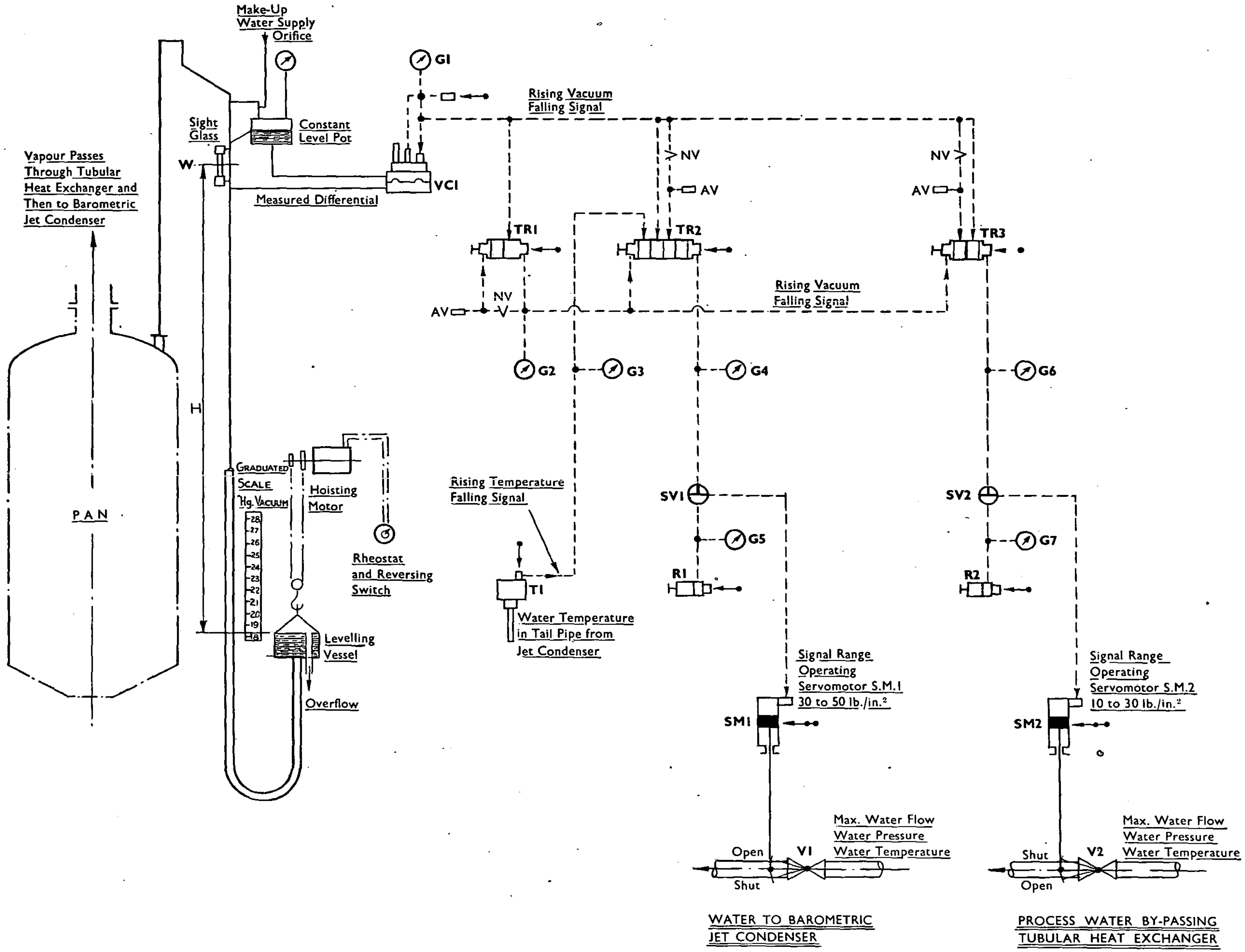
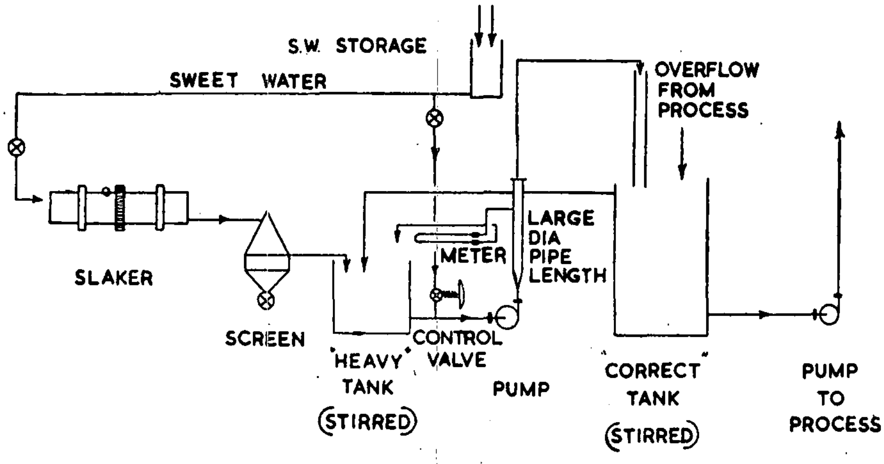

Make-Up
Water Supply
Orifice
G1
Rising Vacuum
Falling Signal
Sight
Glass
Constant
Level Pot
W
VC1
Vapour Passes
Through Tubular
Heat Exchanger and
Then to Barometric
Jet Condenser
Measured Differential
NV
AV
TR1
TR2
TR3
Rising Vacuum
Falling Signal
AV
NV
G2
G3
G4
G6
H
PAN
Graduated
Scale
Hg. Vacuum
28
27
26
25
24
23
22
21
20
19
18
Hoisting
Motor
Rheostat
and Reversing
Switch
Levelling
Vessel
Overflow
Rising Temperature
Falling Signal
T1
Water Temperature
in Tail Pipe from
Jet Condenser
SV1
G5
R1
SV2
G7
R2
Signal Range
Operating
Servomotor S.M.1
30 to 50 lb./in.²
SM1
Signal Range
Operating
Servomotor S.M.2
10 to 30 lb./in.²
SM2
Max. Water Flow
Water Pressure
Water Temperature
Open
V1
Shut
Max. Water Flow
Water Pressure
Water Temperature
Shut
V2
Open
WATER TO BAROMETRIC
JET CONDENSER
PROCESS WATER BY-PASSING
TUBULAR HEAT EXCHANGER

Fig. 2



LAY-OUT OF PLANT

Fig. 3

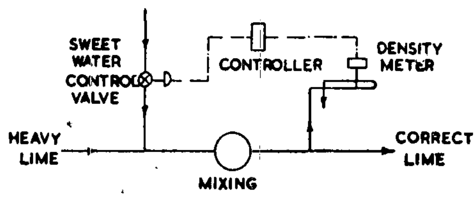
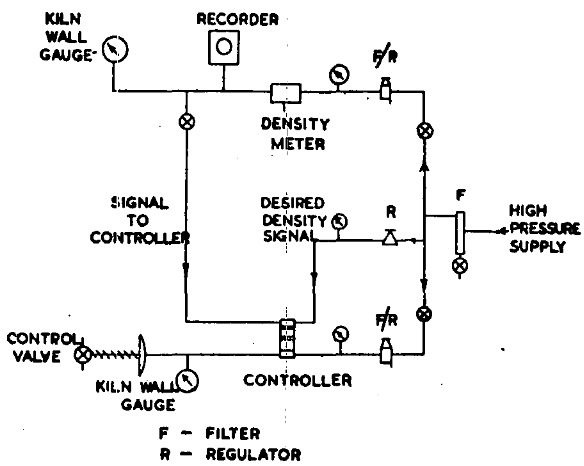


DIAGRAM OF CONTROL SCHEME



LAY-OUT OF AIR LINES

Fig. 4

The air pressure output of the density meter was led to a pneumatic controller with "two-term" or proportional and reset action. The density signal was also applied to a recorder and a large wall gauge to give operators warning if slaking became too light.

The controller output pressure was connected to the diaphragm motor of a double-seated valve to regulate the supply of diluting sweet-water. Between the point of entry of the sweet-water and the sample branch to the density meter there was situated a circulating pump which served to mix thoroughly the two components, as well as to effect transfer from the tank receiving heavy lime to the tank storing correct lime.

Attention to a number of details of the plant layout contributed to successful working. These points included a length of large-diameter pipe, on the side of which was welded a branch for the metering sample; such a branch on the side of a narrow pipe in which a slurry is moving fast can give a sample lighter than the bulk. The automatic control valve was close above the point of entry of diluting water to prevent spurious discharges of the water between and consequent erratic control. The diluting sweet-water was taken from a point which could not become choked by sedimentation. The meter was very near to the sample branch and piped with a minimum of bends, and the discharge arranged above the meter level to ensure the meter running full. It is necessary to size the control valve correctly from valve data in accordance with the dimensions of the plant and the average rate of lime production.

Owing to atmospheric conditions in the lime-kiln house both in and out of the manufacturing season, it was decided to instal the meter and associated control equipment and some electrical kiln instruments in a small windowed building within the kiln house, a practice common in steelworks. This ensures better protection at all times than is afforded by rack and panel mountings.

The short time constants of the system enabled very tight control of density to be achieved. The density meter had a full-scale range of 0.2 s.g. units, and the zero was adjusted to bring 20° Bé. to the centre of the recorder scale, which thus covered approximately 10–30° Bé. Under automatic control, departures from the set-point did not exceed one-hundredth of full-scale deflection, i.e. 0.2° Bé., except when an oversight on the part of the operators allowed the slaking to run light. Advance warning of this would be given by a fall in automatic control valve operating pressure shown on a large wall gauge.

The meter actually read density rather than specific gravity, but a recording thermometer in the milk-of-lime has shown that this was a fact of little consequence in this application. However, the density was partly caused by sugar in the sweet-water. On the plant referred to, the wash-water from rotary filters was always too heavy for slaking purposes and was made down automatically to constant density so that a constant proportion of lime in the milk-of-lime was achieved.

The installation described in this article was developed in a factory of the British Sugar Corporation Ltd., to whom acknowledgement is made for permission to publish this report.

Conclusion

The author has been for these past three years applying instrumentation to the Sugar Industry. Here he found the average sugar technician welcomes the use of instruments, but management fights shy of applying instruments to their plant due to the non-existence of the right kind of labour to maintain and service automatic control.

This is very true: one cannot expect an electrician or a fitter to know how to service an automatic boiler control, or a temperature recorder-controller. One would not expect a fitter to carry out the work of an electrician—it is like fitting a round peg into a square hole.

The Sugar Industry must realise than an instrument mechanic is a specialised and skilled job, equal to that of the electrician or the fitter, and each mill must carry one or two instrument mechanics capable of installing further instrumentation to the industry, and maintain existing equipment. If each mill carried its own instrument staff, I am quite sure that management would welcome automation in the mill. As I mentioned previously, automation means an increase in production and a better product.

I am sure also that the average South African working man is proud of the job he is doing—and he is proud to feel that you are giving him the chance to do it the up-to-date way.

Mr. Narbeth gave a brief history of the development of the instrument described in the paper. This development took place in the British Sugar Corporation's Organisation. He referred to Figure 3 (layout of plant) and called attention to an alternative layout. His remarks were as follows:

"The instrument is a balance and weighs everything passing through it. Thus it is essential that no lumps should pass through. If the milk of lime sample is taken from the "heavy" tank, passage of lumps and grit is unavoidable for screening before the "heavy" tank is rarely efficient; and would not be economical if it were efficient, as the lime is rarely fully slaked before reaching the "heavy" tank and there would be considerable wastage by the rejection of unslaked lime. Thus partial screening should be effected before the "heavy" tank and a very efficient screen installed before the "correct" tank. The sample, therefore, may well be taken from the process circulation line and the water added immediately before the pump, pumping from the "heavy" tank to the "correct" tank to ensure intimate mixing."

Mr. Galbraith reported that the arrangement described by Mr. Narbeth has worked quite satisfactorily at Sezela. This instrument is the only completely automatic control equipment tried out and it proved very efficient. The lime density can be controlled to within ½°Bé. without any trouble, and providad screening is efficient there are no blockages or stoppages. When shutting down for the week-end or any long stop it is only necessary to pump a little hot water through the piping system.

Mr. Bentley said he presumed that the slaking was manually controlled, and it seemed to him to be quite a simple step to take to bring that into line with the rest of the automatic control arrangements.

Mr. Narbeth said that lime slakers frequently have an automatic lime feed but it is not easy to arrange for an automatic *control* before the slaker, as burnt lime is an exceedingly difficult material to weigh correctly automatically, whether the automatic weighing is by batch, or continuous.

Mr. Galbraith commented that even if a fully automatic control included the automatic provision of lime to the slaker, some labour would still be necessary, and with the scheme at Sezela only one unit of labour was required.

Mr. Rault said the workman at the liming and carbonatation tank used a fairly constant proportion of lime by volume—hence the necessity of a constant density lime mean. He wanted to know what would happen in case of a too low density lime cream from the slaker as the instrument could dilute, but not thicken a lime cream.

Mr. Galbraith said this could happen under manual control, but with the new system at Sezela it does not happen. A recorder pinpoints trouble immediately. Before this new system was installed there were all sorts of complications due to the poor preparation of milk of lime, for instance, the lime slaker operator was getting varying densities, as he tested with a spindle, and a spindle will give varied readings for the same actual density, but the new instrument was definitely accurate. To keep a check on the instrument a quantity of milk of lime is occasionally accurately weighed in the laboratory, and the density calculated. This cannot be determined by hydrometer.