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INSTRUMENTATION FOR SUGAR PLANT

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I. INTRODUCTION

In recent years, the rapid progress in integration and automation of the production equipment in all industries has been truly spectacular. The sugar industry is no exception : each branch of this industry has developed to the extent that larger scale measuring control equipment is required for the more complicated functions. To cope with this demand, this company has inaugurated in each control system the all-electric TELEPERM system, a combination of the all-electric TELEPERM system and all-pneumatic TELEPNEU system.

In this article, we will introduce a sugar plant measuring control system that has adopted a TELEPERM-TELEPNEU system.

II. SUMMARY OF SUGAR MANUFACTURING PROCESS

Before going into an explanation of the measuring control system, we wish to summarize the sugar manufacturing process. *Fig. 1* is a flow chart of the principal processes. The sugar beet brought into the plant is washed thoroughly in a washer and then sent to a slicer. The sliced beets are called cossettes. The cossettes, after they have been heated in a heater, are sent to the diffuser. The raw juice treated in the diffuser with warm water is then rid of impurities. This very important cleaning process affects the quality of sugar, cost and efficiency of the plant ; it is composed of pre-liming tank, main liming tank, first and second carbonators, sulfiter and all types of filters. To the raw juice which is sent to the pre-liming tank is added some limed juice taken from the outlet of the main liming tank. The raw juice thus mixed with limed juice is sent to the main liming tank and is further mixed with lime milk, a uniform mixture of lime and water from the lime milk tank.

The raw juice is subsequently sent to the first and second carbonators to be saturated with carbon dioxide gas. The lime which had been added to the raw juice combines with the carbon dioxide gas to form calcium carbonate which is filtered out, along with other impurities, by the filters located at the back of the carbonators.

The filtered raw juice is now sent to the sulfiter for sulfurous acid gas treatment and then to the

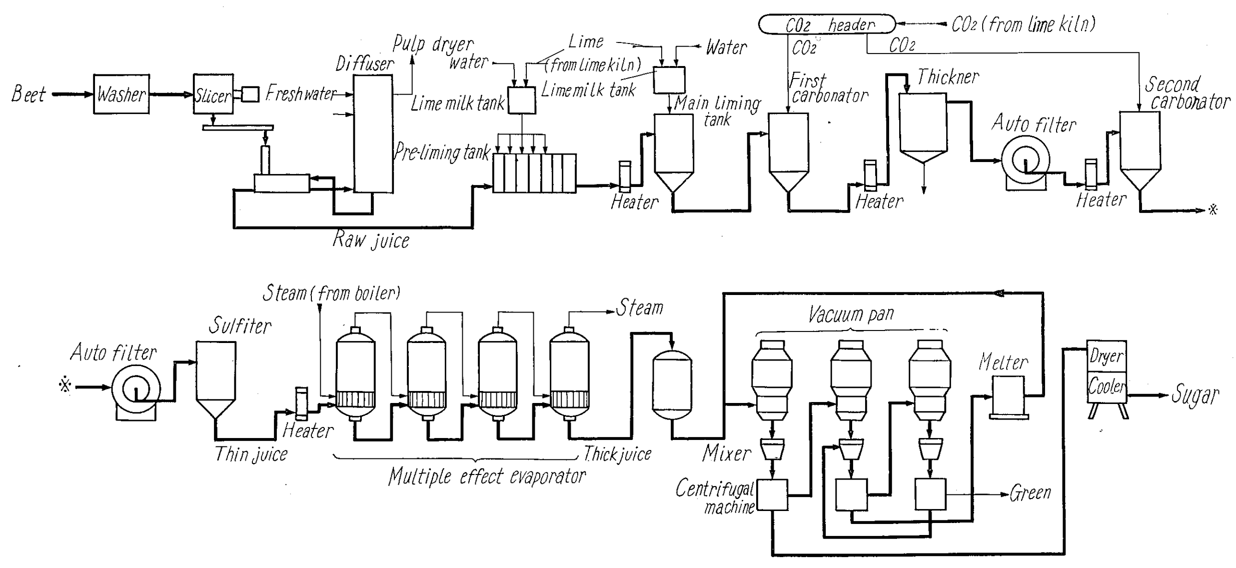

Fig. 1 Schematic diagram of sugar plant

multiple effect evaporators for concentration process. The raw juice that enters the multiple effect evaporators has a sugar content of about 13~15% ; the evaporating process raises this percentage. The steam for the first evaporator is supplied by a boiler but the steam for the second evaporator is the steam that has been generated when the juice was concentrated in the first evaporator and re-utilized. The steam for the third evaporator is that extracted from the second evaporator and the steam for the fourth evaporator is that extracted from the third evaporator.

The concentrated juice from the multiple effect evaporator is sent to the vacuum pan and here sugar crystals are formed for the first time.

These crystals are separated by a centrifugal machine and dried in a dryer.

Besides the above equipment, there is other equipment, such as a dryer for the manufacture of dry pulp for feed.

III. EXPLANATION OF MEASURING CONTROL SYSTEM

This measuring control system will be explained in four divisions : processes of cleaning, concentrating crystallization and pulp drying.

Instrument panels are located on the actual sites where each process takes place.

1. Cleaning Process

This process includes all operations between the pre-liming tank and the sulfiter. As it has been stated before, since this process is one of the most important processes in a sugar plant, an emphasis has been placed on the instrumentation of this process. *Fig. 2* shows the instrument panel for this process and *Fig. 3* shows the instrumentation diagram.

1) PH recording and controlling device for pre-liming tank

The raw juice that is extracted from the beet in the diffuser is sent to the pre-liming tank and is mixed with some juice with high lime content, namely the limed juice, taken from the outlet of the main liming tank. Therefore, the detecting quantity of this measur-

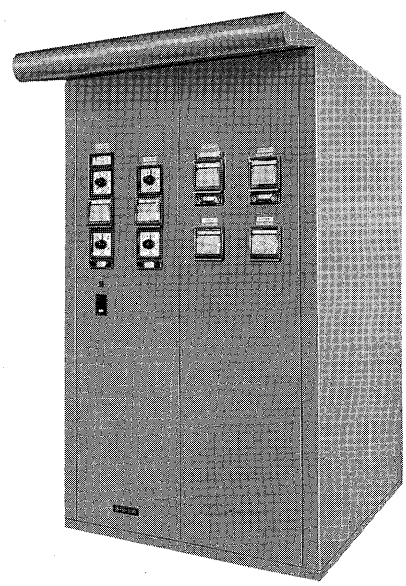

Fig. 2 Instrument panel

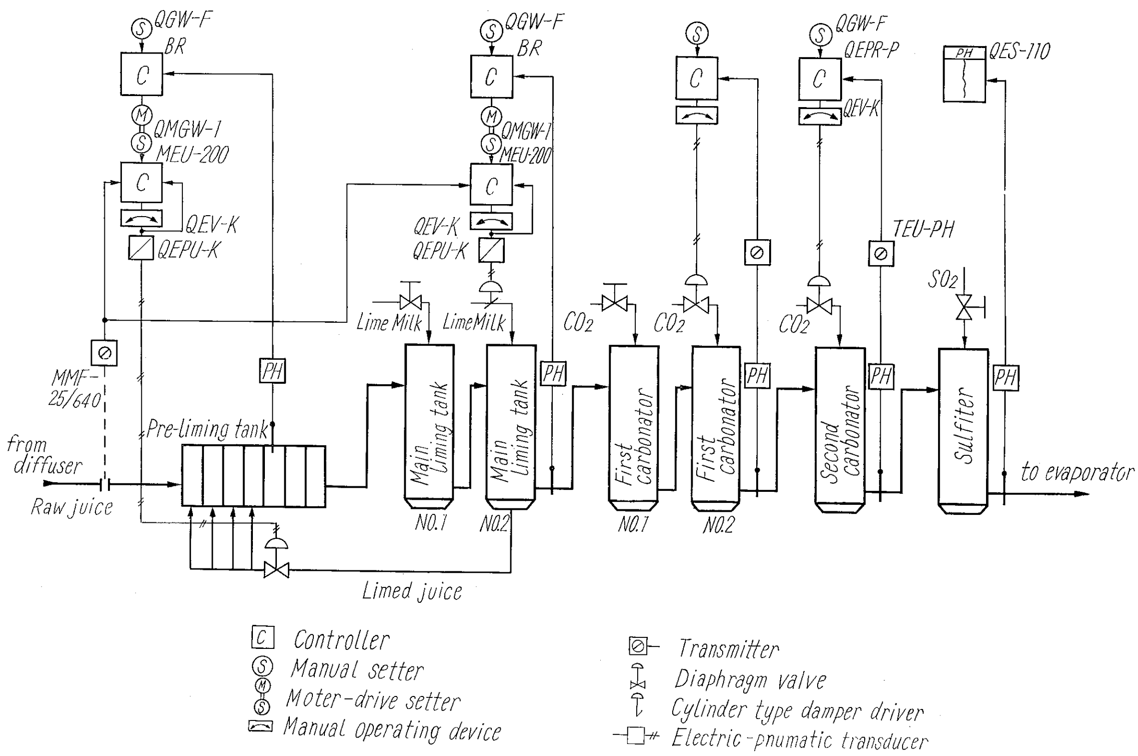

Fig. 3 Instrumentation diagram of cleaning process

ing control system is pH value of the pre-liming tank outlet and the operating quantity is the limed juice flow amount. The value of pH of the pre-liming tank is measured with a glass electrode and compared with the pH pre-set value using a sampling type pH controller. This pH controller operates an electric raw juice-limed juice flow ratio setting device (model QMGW-1) by positive and negative pulses and cascade controls a TELEPERM type flow ratio controller (MEU-200). For this controller, the raw juice flow which has been transduced into a direct current by a Venturi short tube and the TELEPERM type flow transmitter (MMF-25/640) and the controller output signal, namely the limed juice flow, constitute the input. Further, in order to equate the output signal of the flow ratio controller and the flow of the limed juice, a special consideration was given to the Sanders control valve and design of the plant.

Accordingly, if these two flows do not conform to the values set by the ratio setting device, the flow ratio controller operates the Sanders valve and controls the limed juice flow to match the set value. The electrical output signal of the flow ratio controller is transduced into pneumatic signal of 0.2~1.0 kg/cm^2 by the electro-pneumatic transducer (QE PU-K). In this controller, the following three points presented problems:

(1) PH transmitter

Because the raw juice at the detecting point is at high temperature and contains scales, we used a large pH transmitter generally used for sugar juice.

(2) Flow meter and control valve for the limed juice

As the limed juice contains a large quantity of lime, we thought that the use of a flow meter would be extremely difficult, so we used the output signal of the raw juice-limed juice flow ratio controller as the limed juice flow amount. A cam type positioner was attached to the control valve to set a maximum flow and to give it linearity. For the plant side, a precaution was taken to prevent a dissimilarity between the control valve's specific and effective characteristics.

(3) Time lag of processes and pH transmitter

As the process disturbance is caused by the raw juice flow, the raw juice and limed juice flows were controlled proportionately and were cascade-controlled by the pH controller.

2) PH recording and controlling device for main liming tank

The raw juice, which had been mixed with limed juice in the pre-liming tank, is sent to the main liming tank and lime milk is added. Therefore, the quantity detected by this control device is the pH value at the main liming tank outlet and the operating quantity is the lime milk flow.

The pH value of the main liming tank is measured with a glass electrode and is compared with the pH set value using a sampling type pH controller. By means of positive and negative signals, this controller operates the electric raw juice-lime milk flow ratio setting device (QMGW-1) and cascade-controls the TELEPERM type flow ratio controller (MEU-200). The input for this flow ratio controller is the raw juice flow which was used for the pH flow ratio controller for the pre-liming tank and the controller output signal which is the lime milk flow. Considerations were given to the plant design to equate the output signal of the flow ratio controller and the lime milk flow. Accordingly, if these two flow amounts do not match the values set by the ratio setting device, this flow ratio controller activates a power cylinder to control the lime milk flow to match the set ratio. The electric output signal of the flow ratio controller is transduced into pneumatic signal by an electro-pneumatic transducer. This measuring control device also has the same problems as the pre-liming tank pH controlling device.

3) PH recording and controlling device for first and second carbonators.

The raw juice which had been mixed with lime in the pre-liming and main liming tanks is given carbon dioxide gas treatment in first and second carbonators; the previously added lime combines with carbon dioxide to form calcium carbonate which settles together with impurities. Therefore, the detected quantity of these controllers is the pH value at each carbonator outlet and the operating quantity is the carbon dioxide gas flow.

Fig. 4 shows a pH transmitter installed on the second carbonator. The pH value at each carbonator outlet is measured with a glass electrode, is trans-

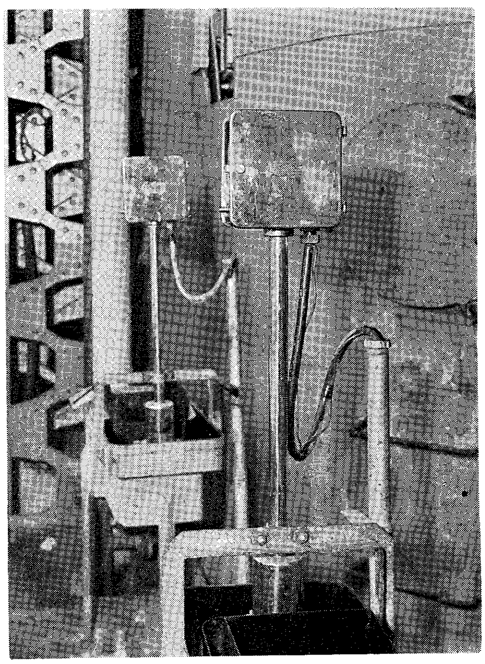

Fig. 4 PH transmitter on second carbonator

duced into a direct current by TELEPERM type electric transducer (TEU–PH), and becomes the input for the Q series electro-pneumatic pH controller (QEPR–P). The controller is set at any desired pH value by the Q series operating device (QPV–11) which has automatic-manual change-over device, manual operating device, setting device and double needle type operating pressure gauge. This controller operates, through its operating device, the diaphragm control valve to control the carbon dioxide flow. Thus, the pH value at each carbonator outlet is adjusted at its proper value.

The problems of these controlling devices are the selection of pH transmitter to be used, as was the case with the pre-liming and main liming tanks, and the pressure variation of the carbon dioxide gas. The pressure variation is a problem because it causes a flow variation which in turn becomes a disturbance in the flow system. To prevent this gas pressure variation, we used a carbon dioxide gas header to stabilize the pressure.

4) PH recording device for sulfiter

The raw juice that comes out of the second carbonator is sent to the sulfiter to be treated with sulfurous acid gas. In this process, only pH recording was done using a Q series electron tube type, automatic balanced pH recorder (QES-110) but pH controlling was not performed.

If pH and sulfurous acid gas pressure are to be controlled in this process, a special consideration must be given to the selection of the material for the detecting and operating ends.

5) PH indicating device for each point

The pH value is recorded by an instrument panel at the outlets of the following: No. 5 and No. 7 pre-liming tanks, No. 1 and No. 2 main liming tanks, No. 1 and No. 2 tanks of the first carbonator, second carbonator and sulfiter tank. Furthermore, to indicate pH of each point and for easy operation, two large electron tube type balanced automatic pH indicators were installed at the places which can be seen from any point of the cleaning process. Each of these indicators is equipped with an indicator panel that shows each measured point by light.

6) Other equipment

Besides the devices described above, the cleaning process stage has a recording device that analyzes the carbon dioxide gas generated in the lime kiln and a control device that keeps a uniform pressure of the carbon dioxide gas drawn into the first and second carbonators.

2. Evaporating Process

This process is made up of the thin juice tanks, No. 1, No. 2, No. 3 and No. 4 evaporators. *Fig. 5* shows the instrument panel for this process and *Fig. 6* is its instrumentation diagram.

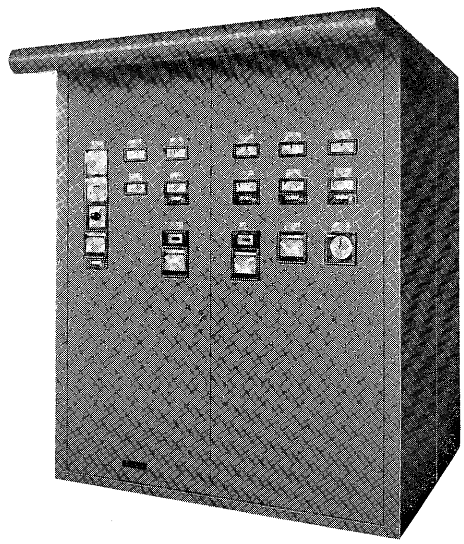

Fig. 5 Instrument panel

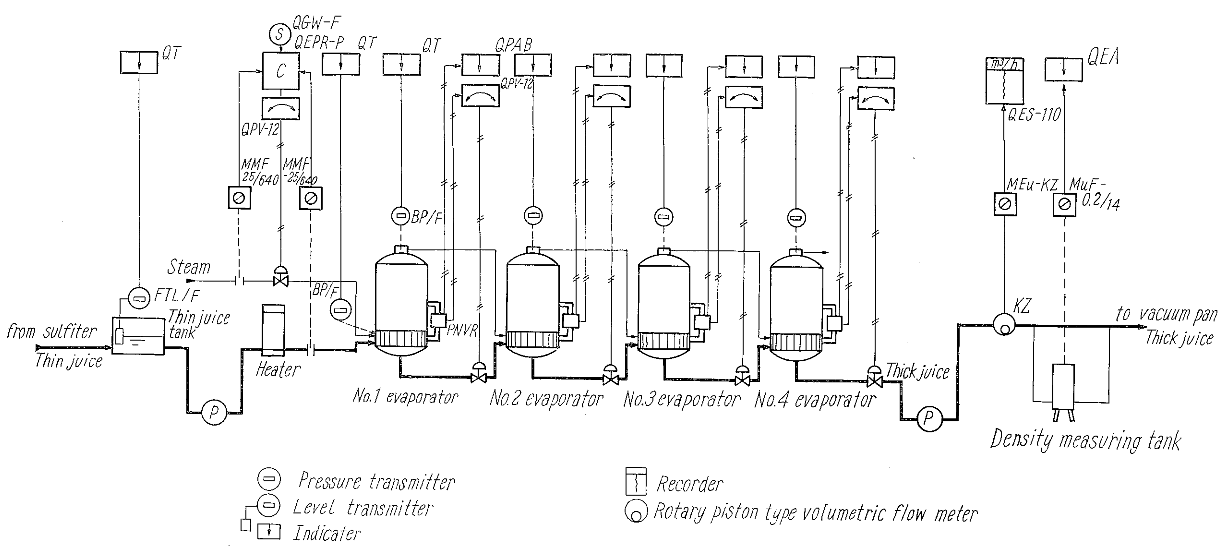

Fig. 6 Instrumentation diagram of multiple effect evaporator

1) Level controller for No. 1∼No. 4 evaporators

This controller's detecting quantity is each evaporator's juice level and its operating quantity is the juice flow at the outlet of each evaporator. *Fig. 7* shows a level controller installed on an evaporator. The juice level is measured by a deflection type level controller (PNVR–H3). This level controller controls the juice flow at the outlet of each evaporator by operating the diaphragm valve so that the liquid level will be the same as the value set by a built in level setting device.

A precaution that must be heeded in the planning of this measuring control device is the selection of a proper diameter of the diaphragm valve which is to be installed at the outlet of each evaporator. The reason for this is that bacause the juice at the outlet of evaporators is in a saturated state, it sometimes " flashes " immediately after passing the control valve and prevents a necessary free flow. It is necessary that the actual control valve diameter be a bit larger than its calculated value.

2) Density indicating device for No. 4 evaporator

A portion of the juice at the outlet of No. 4 evaporator is led into a measuring tank for density measurement. This measuring tank is made up of double cylinders ; the juice for density measurement is drawn into the inner cylinder and warm water is drawn into the outer cylinder. The purpose of this warm water is base compensation. Into the juice and warm water of this measuring tank are inserted the tubes of an air purge type density transmitter. The back pressure is measured by a TELEPERM type differential pressure transducer (MUF–0.2/14) and is changed into a direct current ; this direct current, namely the specific gravity, is indicated by a Q series electron tube type automatic balanced indicator (QEA). However, the specific gravity of the juice and warm water is affected temperature; to compensate this a platinum temperature measuring resistor is placed in the juice and warm water so that the indicator will indicate the density of each at a standard temperature. *Fig. 8* shows density measuring tank and density transmitter.

3) Other equipment

The evaporating process, besides the above, is equipped with the following :

- 1 set × thin juice level indicator
- 1 set × thin juice flow—No. 1 evaporator steam flow ratio controller
- 1 set × No. 1 evaporator calendria pressure indicator
- 1 set × No. 1∼No. 4 evaporators pressure indicator
- 1 set × No. 1 and No. 2 evaporators extracted steam flow quantity recording and counting device
- 1 set × thick juice flow quantity recording and counting device

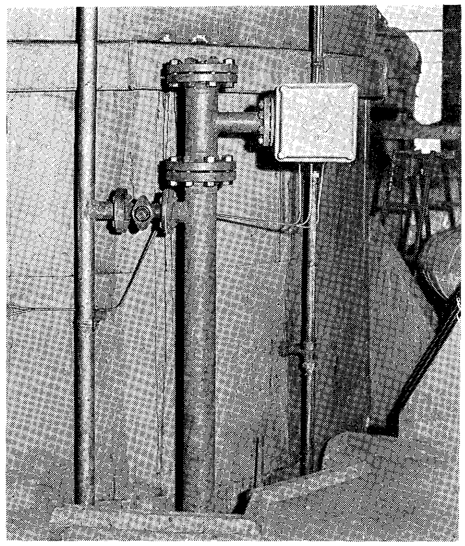

Fig. 7 Level controller on evaporator

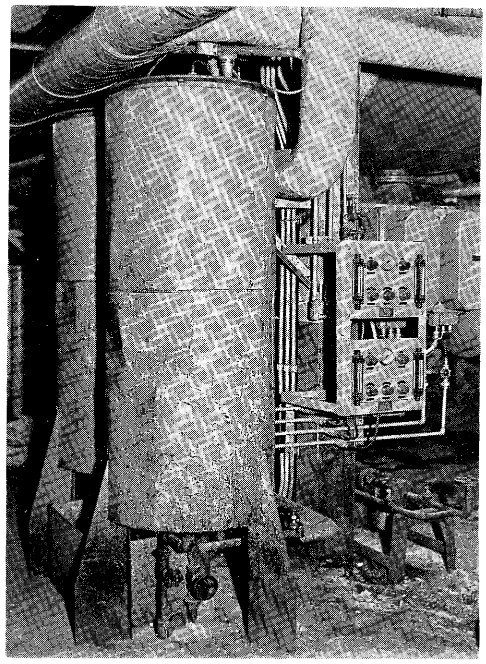

Fig. 8 Density measuring tank and density transmitter

3. Vacuum Pans

For this process, the equipment was limited to a flow quantity counting device for adding water and steam flow quantity counting device. However, as indicated by various reports and literature, this process, too, will gradually be automated.

4. Pulp Drying Process

As this process is regarded as an accessory facility to a sugar plant, we did not automate it at this time ; however, the following supervisory equipment was installed :

1 set × pulp flow stop warning device
1 set × temperature recording device for the kiln inlet and outlet
1 set × furnace interior pressure warning device

IV. Conclusion

We have given above a summary of a TELEPERM-TELEPNEU type measuring control device for a sugar plant. We are desirous in the future to pilot every process of a sugar plant by means of concentrated control system which uses TELEPERM type, TELEPNEU type and TELEPERM-TELEPNEU type as its center, with an inclusion of the data logger which in recent years has been used positively by many industries.