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INSTRUMENTATION FOR PAPER-PULP PLANT

By Yuki Ito
Instrumentation Technical Sect., Central Technical Dep't.

I. INTRODUCTION

Recently, the instrumentation of paper-pulp plants has assumed a greater magnitude, with more centralized supervision of all processes. The method of instrumentation is changing from the limited use of large pneumatic instruments to the implementation of new and smaller electronic instruments of varied types. Engineers have also instituted the use of loggers and computors in the instrumentation of paper-pulp plants.

Fuji Denki's TELEPERM and TELEPNEU system, greatly responsible for this progress in instrumentation, are extensively used in the paper-pulp plants. We will describe several actual applications of the TELEPERM-TELEPNEU system in the instrumentation of paper-pulp plants and their outstanding features.

II. A SUMMARY OF PAPER-PULP PLANT

Although the paper and pulp manufacturing processes differ somewhat according to products produced, they can be summarized as shown in *Fig. 1*.

The pulpwood is peeled, cut, and reduced to chips in the crushing process and sent to a digester. Here chemicals (sulfites and alkalis) are added and the chips are cooked and digested under a set pressure and temperature. When the chips are digested, they are washed and sorted into fibers and waste solution. Then, after the fibers are washed several more times, they are sent to a disintegrating and screening process, which removes impurities and refines fibers into pulp, which is then bleached, if necessary. In the stuff process, several kinds of pulp are mixed in proper proportion to compose a pulp of a particular quality. Several kinds of chemicals are added at this point to give luster, transparency, density, etc., which a paper is required to possess. After the stuff process, the pulp becomes paper, which is dried in a dryer. The dried paper is further glazed and smoothed by a calender, and rolled up on a reel to become finished product.

The recovering process is a process separate from the manufacture of paper itself: heat and chemicals from waste solutions are recovered and reclaimed here.

As a special example of paper-pulp plant, let us consider the hardboard industry: the pulp made is heated and pressed, given another heat treatment and moisture treatment before it becomes a desired product. The instrumentation of this plant can be handled in the same way as that for a paper-pulp plant.

III. INSTRUMENTATION OF PAPER-PULP PLANT AND TELEPERM-TELEPNEU SYSTEM

Instrumentation of a paper-pulp plant is performed at each of the process stages described above; but each process has its own special features. The instrumentation, however, is usually installed inside and the associated wiring and piping works present no problem. For this reason, a pneumatic type of instrumentation has proven the most popular. The detecting ends employed for pulp are of special types. For level measuring, gamma ray level transmitter, bunker level transmitter, etc., are used; for density measuring, pulp density meter, black liquor density meter, chemical solution density meter are used. Other meters used: magna flowmeter, beta ray thick-

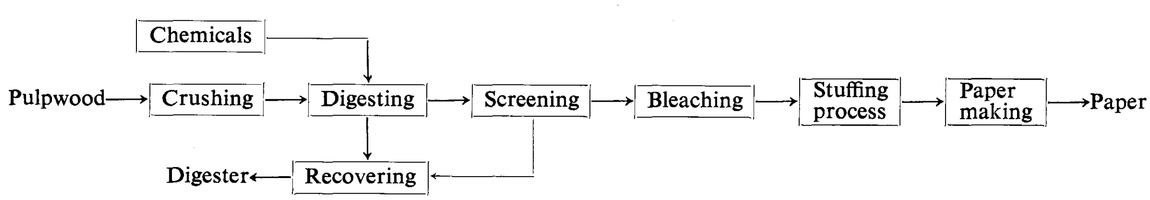

Fig. 1 Schematic diagram of paper-pulp process

ness meter, moisture meter and analyzer. Because of these detecting ends' special characteristics and complexity, the transmitters are necessarily electrical as well as the signal transmission. The problem of the detecting ends is not the only factor that dictates the use of electrical transmitter. The tendency toward a centralized supervision of instrumentated plants and ever-increasing adaptation of data loggers and computors in instrumentation will make all the transmitted signals electrical signals. From the above, one may assume that future instrumentation of paper-pulp plants will definitely involve pneumatic and electro-pneumatic systems. When this happens, the TELEPERM-TELEPNEU system will exhibit its versatility. For example: the electric and pneumatic changing of the detecting and operating signals may be varied in many ways, a prerequisite and convenience for this type of instrumentation. Especially as the signals are transduced at the controller either way, an electro-pneumatic positioner is not required at the operating end.

In a system which uses both pneumatic and electro-pneumatic types, the pneumatic controller (model QPR) and electro-pneumatic controller (QEPR) are (a part of input section excepted) the same, not only in principle but also in construction. These are unit types which use the same parts; since the parts are inter-changeable, their handling and maintenance are simplified and the assembling of equipment in setting up the control system is identical. The recorders, indicators, operating device, etc., for the pneumatic and electro-pneumatic systems are the same in external appearance. Thus these instruments can be mounted on panels in an orderly way.

For the instrumentation of a paper-pulp plant using a mixed pneumatic and electro-pneumatic system as the main control, the TELEPERM-TELEPNEU system, in which the parts and instruments are interchangeable and which incorporates a variety of electro-pneumatic transducing methods, is a system best suited.

IV. EXAMPLES OF PAPER-PULP PLANT INSTRUMENTATION

The versatility of the TELEPERM-TELEPNEU system when utilized in the instrumentation of paper-pulp plants is illustrated below:

1. Instrumentation of Stuff Process

A summary of instrumentation and a schematic diagram of this process are shown in *Fig. 2.* In

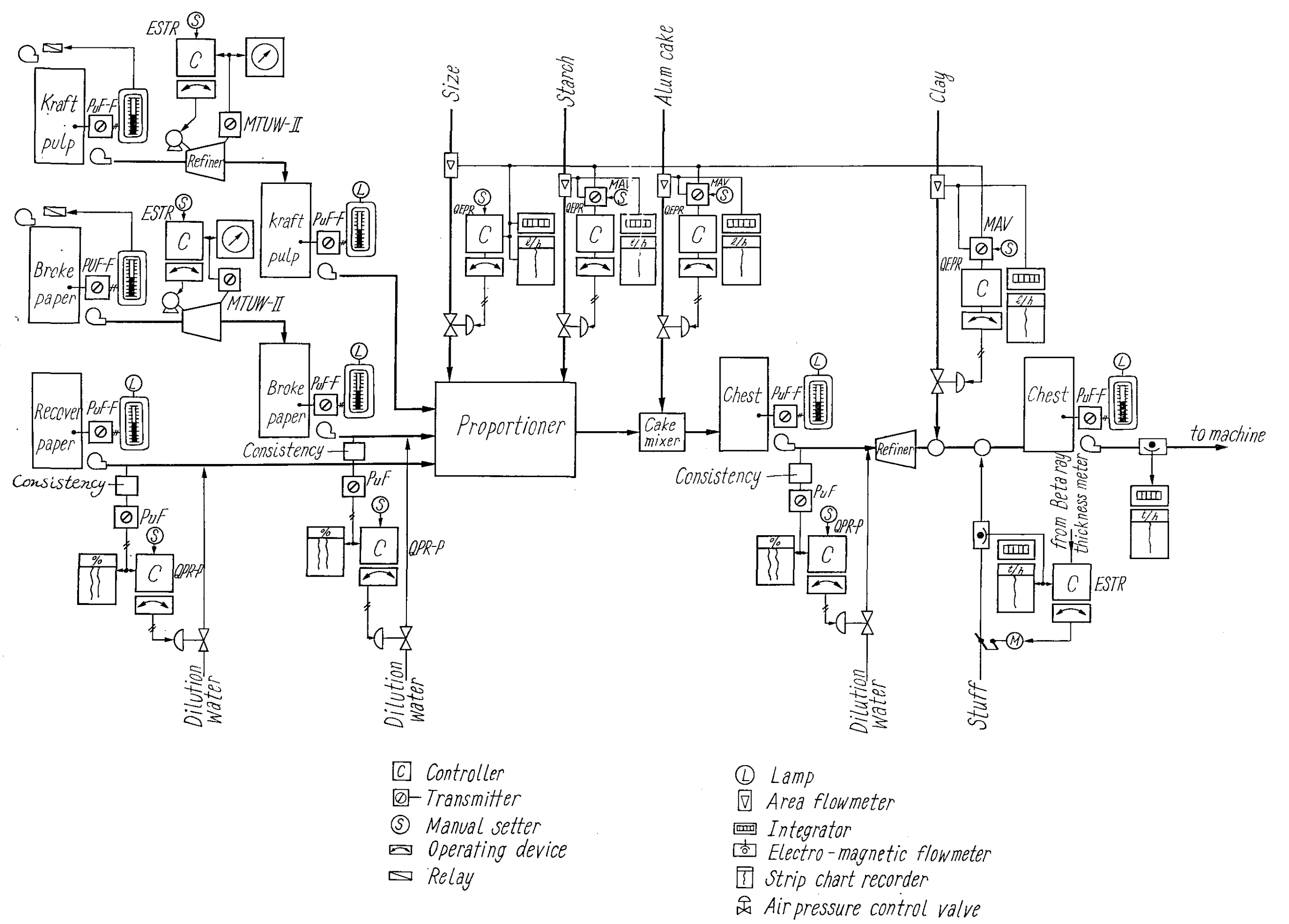

Fig. 2 Instrumentation diagram of stuff process

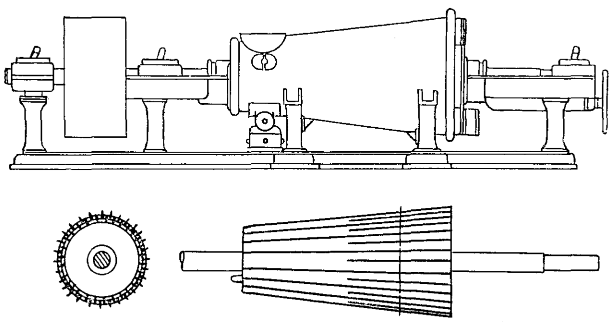

Fig. 3 Refiner

order to obtain a desired paper quality, several kinds of pulp are mixed in proper proportion with certain chemicals. The various half-stuff that enter the stuff process of *Fig. 2* are beaten in the Jordan and Refiner and sent to the chest for storage. Mixed then by a proportioner, size, starch and color are also added. The stuff is sent to a mixer where it is mixed with alum, and sent to the next chest for storage. The stuff that comes out of the chest is refined again in refiner, mixed with clay before it reaches a desired quality state. The finished paper stock is adjusted to required density and is stored in stock chests until it is sent to the paper making process. The main object of the instrumentation is accuracy in obtaining a desired paper quality by controlling the mixing ratio of pulp and chemicals, determining pulp density and monitoring the levels of the numerous chest.

1) Instrumentation for liquid level measuring

In paper-pulp plants, many pulp chests are located between the processes for storage and buffer purposes. Accordingly, the instrumentation for level measuring plays a comparatively important role. For level measuring, air purge type (AP–1) and water purge type (WP–1) level transmitters are usually used, but the flange type diaphragm level transmitter (PuF II–F) is being used more and more. For high density stuffs (over 10%), bunker level transmitter (BL/F) or gamma ray level transmitter is used. The bunker level transmitter was used experimentally on the pulp with excellent results: it is expected that this level transmitter will be utilized extensively in the future. Because the L is small and the T is comparatively large in the level control, an on-off control or P action control is sufficient. In this case, a screen type level indicator (QPAB–2K) with upper and lower limit contacts is used to indicate a quasily level; at the same time, on-off controls at the limit contact or issues level warning. In the case of P action, a separate pneumatic controller (QPR) and operating device (QPV) can be used in combination. In this manner, when warning, on-off or P action control is required, necessary equipment can be added to the principal indicator each time for varied applications. This is the outstanding advantage of the unit system of the TELEPERM-TELEPNEU system. The operation shown in the diagram is done by the pump motor on the chest feed side.

2) Instrumentation of flow measuring

In this instrumentation, the instrumentation for the pulp and chemical flows form the main ones. Pulp flow measuring is erratic because wood fibers clog the flow. If the flow to be measured is that of thin liquid, an area flow meter (MTA) is sufficient; however, for liquids with higher density, a magnetic flow meter becomes necessary. Since the output is transduced into a TELEPERM current (0∼50 mA), a recorder (QDS) and an integrater (QDZ) can be used in series for recording and integrating. If controlling action is needed, the electro-pneumatic controller (QEPR) and operating device (QPV) can be added; all these can be connected by simply plugging in. Here again the standardization of signal current and the advantage of electric current system is noted. For the operating ends for the pulp flow control, rubber-lined Sander's valve and butterfly valves are used to prevent clogging and corrosion.

The chemical flow control is very important but difficult. The amount of the chemicals to be measured is very small but the least variation in the amount greatly affects the quality of paper produced.

In this case, the controller used is a small quantity type flow rater (AMTF) for electrical transmitting TELEPERM system. Since each chemical needs to be added at a set ratio, each chemical flow is controlled by a ratio calculator (QGW+MAV). The amount of the chemicals to be added should be controlled proportionately to the amount of pulp; but since the pulp amount, in this example, is controlled at the outlet motor, the flow controlling was limited to the chemicals. Because of the set pulp amount, the required amount of the chemicals is set manually. However, there is another method: the chemicals measured by a quantity metering pump.

The electrical transmitting flow-rater is an area type flow meter to which a TELEPERM "Apgrif" transducer has been combined which transmits current by changing the rotation displacement into

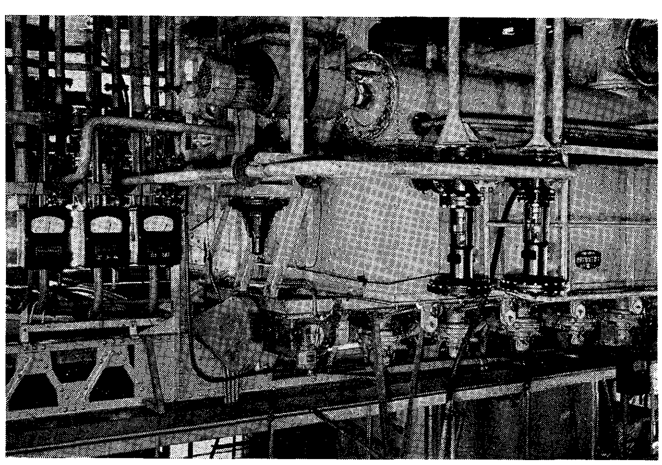

Fig. 4 Area flowmeter and diaphragm control valve at proportioner

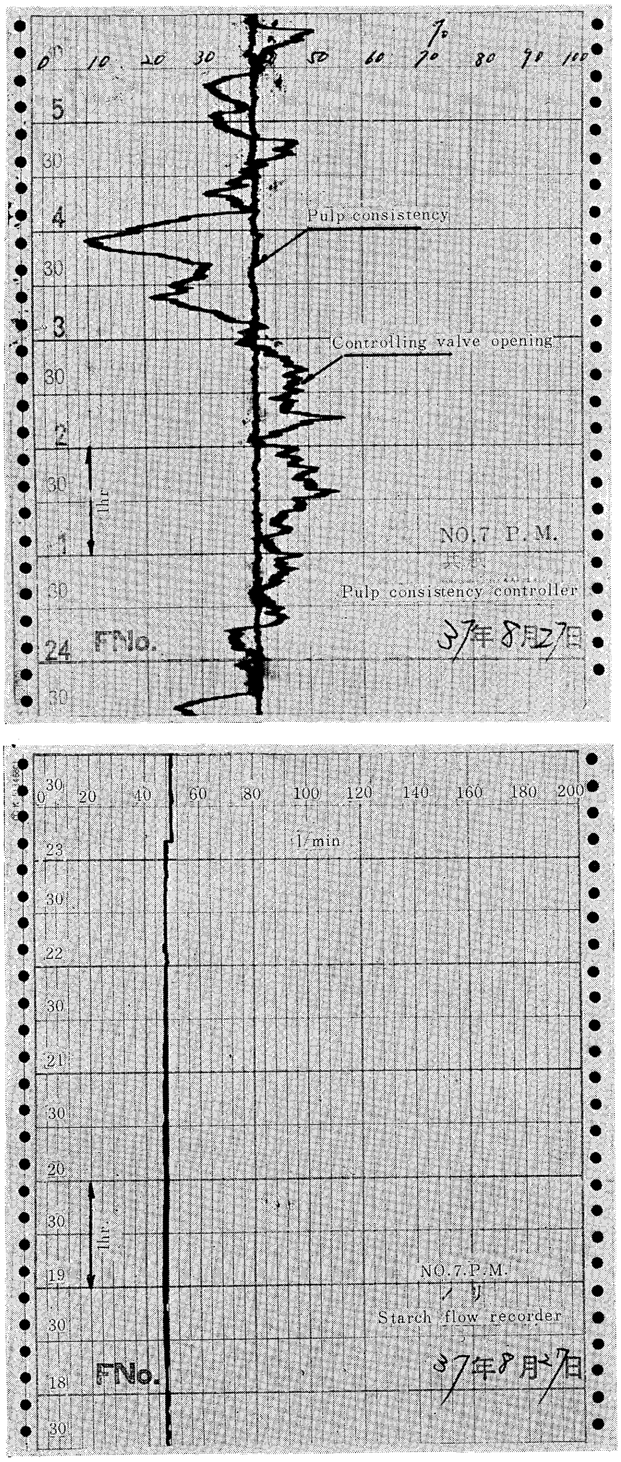

Fig. 5 **Charts of pulp consistency and size flow**

current 0～50 mA. Accordingly, it constitutes an FRSC system together with recorder (QDS), integrater (QDZ) and electro-pneumatic controller (QEPR). The area flowmeter and diaphragm control valve of a positioner are shown here.

A recording example of pulp consistency and size flow control is shown in *Fig. 5*.

3) Instrumentation for density measuring

In the stuff process, where pulp mixing and chemical addition occurs at many points, pulp density control becomes necessary, as it does for the subsequent process of pulp beating. In this example, the density transmitter used is a " Dezlick " agitator type in which the density is adjusted with diluting water. Since the transmitter issues pneumatic signal, recorder (QPS) and controller (QPR) are used in the pneumatic system. This recorder is convenient ; because of its three input elements, the recorder records the density and valve opening and indicates set density value. The paper thickness is usually measured near the calender of the paper making process and is controlled by mixing of stock at the stuff process.

The thickness meter used is a beta ray thickness meter and transmits the TELEPERM signal electrically. This signal is cascaded to the setting of the stock flow controller (ESTR) (intermittent type) through the continuous type controller (EKR). In this system, because of the wide distance between the detecting ends and operating ends, an ordinary controller will not work because of the interval of detecting time. For this reason, an adjustable sampler is installed at the controller input to maintain a time control that corresponds to the process' dead time. This flow controller is a TELEPERM intermittent type ; a large filter in its input circuit eliminates high frequency noise, yet does not affect the controlling action. Accordingly, the controller issues a pulse of a length proportional to the variation of the thickness of paper ; as the pulse ends, the controlling action registers for only predetermined duration for maintaining operation. The controller performs a controlling action anew as soon as the sampler functions ; this controlling action is such that the integrating time appears to be fully lengthened. Controlling action such this is performed easily in TELEPERM intermittent type controlling system because the control signal depends on the intermittent pulse.

A specific example is the controlling of the refiner blade feed. This maintains a set amount of beating of the pulp by controlling the blade feeding in relation to the pulp amount inside the refiner and the degree of beating. The detecting of the pulp amount and degree of beating depends on the electric power of the refiner using a torque-balance type, continuous power transducer (MTUW–II). The controller is a TELEPERM intermittent type controller (ESTR), used to drive a pilot motor for the refiner blade feed with its impulse signal. Since the on-off signal of the controller drives the motor at the operating end, it is easy to select operating end ; moreover, as the pulse length and spacing can be controlled quite finely, this controller is well-suited for the controlling of the feed of the refiner blade. In this case, as there is no time lag on the process side, a short time feed back type is used. As it can be seen from this example, because the operating signal is obtained in the form of a pulse in the TELEPERM intermittent type controller (ESTR), the selection of operating end is easy ; the controller can also be used in processes with large dead time and time constant by proper selection of short or long time length for the feed back circuit. On the other hand, as this controller can also be used in systems with quick responses, it can be called a very flexible controller.

2. Instrumentation of Digester

A summary of this process and a schematic diagram of its instrumentation are shown in *Fig. 6*. The digesting process is one where wood chips are digested in a digester to produce pulp. There are two types of digesting methods: a continuous digesting and batch type digesting. In this discussion, the batch type will be described because of its simplicity. The wood chips are fed into the digester to be mixed with chemicals according to a time schedule set up inside the digester under predetermined pressure and temperature. In the high temperature and high pressure digesting process, the lignin and other non-fibrous materials and impurities are removed to obtain fibers in comparatively pure form. The relationship between temperature, pressure and time laps of this process is a very important factor that affects greatly the quality and strength of the finished paper. Therefore, the instrumentation of this process controls the temperature and pressure according to a set schedule and a programmed control of temperature and pressure constitutes the main portion.

One processing time is approximately 4∼5 hours; the temperature is 0∼200°C; the pressure is roughly 10 kg/cm^2.

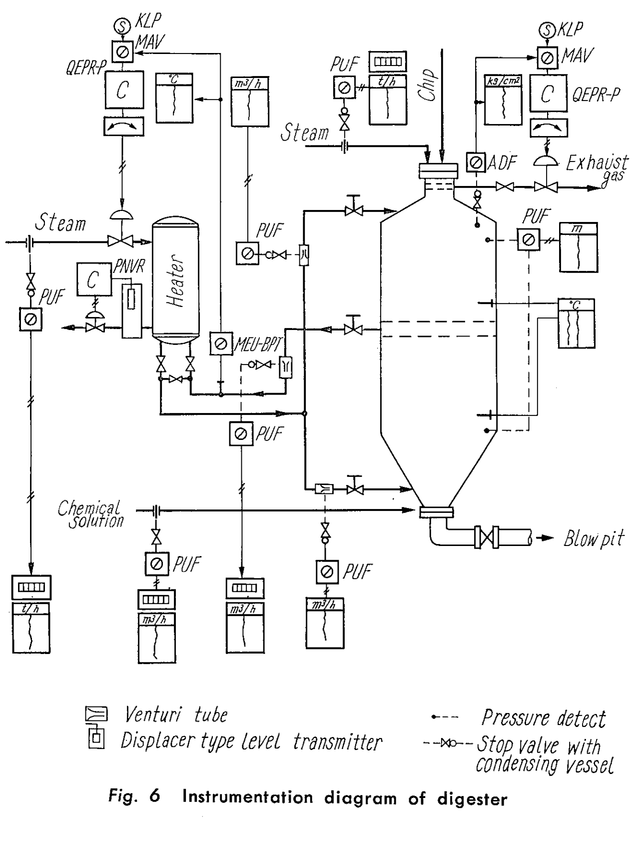

Fig. 6 Instrumentation diagram of digester

1) Instrumentation for temperature control

The most important matter in this instrumentation is the temperature control of the chemical solutions. A platinum resistance thermometer detects the temperature of chemical solutions at the outlet of the heater. This reading is transduced into a TELEPERM current by an electric transducer (MEU-BPt) and is sent to a differential amplifier (MAV) and a recorder. The setting is a programmed control and for that an electronic self balancing photo-electric program setter (KLP) is used. In this method, making or changing of programs is easy because the programs are written on "miler" sheet with magic ink pen. The setting values are transmitted in the form of resistance. Depending on operation, the program may be set for continuous automatic repeating or for single process, by using the program setter of a rewinding type. This set value and detected temperature are compared in the differential amplifier and sent to electro-pneumatic controller (QEPR) in the form of a differential signal. Accordingly, the calculation is made in the form of an electric signal, the operating signal made in pneumatic signal form. Besides, the temperature of the interior of the digester is measured and recorded directly by an electronic recorder (QES).

2) Instrumentation for pressure control

The digester pressure is also program controlled in parallel with the temperature. A Bourdon gauge is used as a detecting end and pressure measuring is done at the top of the digester. Because the wood fiber contained in the digester gas is liable to clog the detecting hole, a stop valve with a condenser is utilized and the pressure is measured through the water. The value measured is changed by an "Apgrif" transmitter directly into a TELEPERM current. Therefore, after a pressure detection, the same program setter, electro-pneumatic controller and recorder used as the temperature control can be used. The operating end is done by releasing the gas by means of the gas releasing valve; a precaution must be taken against corrosion and clogging wood fiber in the gas.

3) Instrumentation for flow control

In this instrumentation, the measurement of the circulating chemical solutions forms the main control. Sources of problems in instrumentation: high temperature, pressure and corroding effect of the chemicals, clogging caused by wood fibers and the direction of attaching the detecting end. In this example, a Venturi tube and sealing pot are used; the detecting method by means of differential pressure. In this example, since the transmission distance is short and the system simple, the system used is a pneumatic system in which a TELEPNEU differential transmitter (PuF) as the transmitter is connected to a pneumatic recorder (QPS) and integrator (QPZ). *Fig. 7* shows the condition of differential pressure detecting.

Besides the above, the measurement of the digester interior liquid level is done by detecting the differential

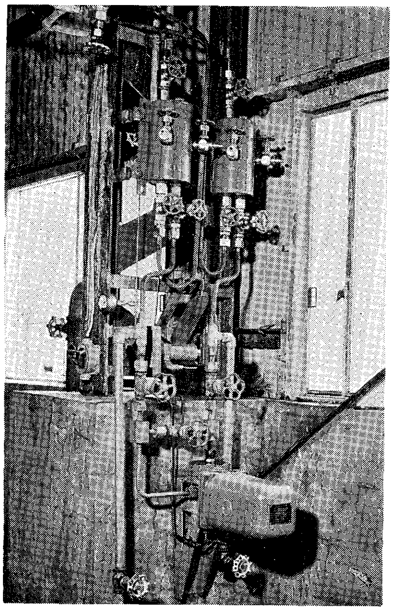

Fig. 7 TELEPNEU-differential pressure transmitter with seal pot

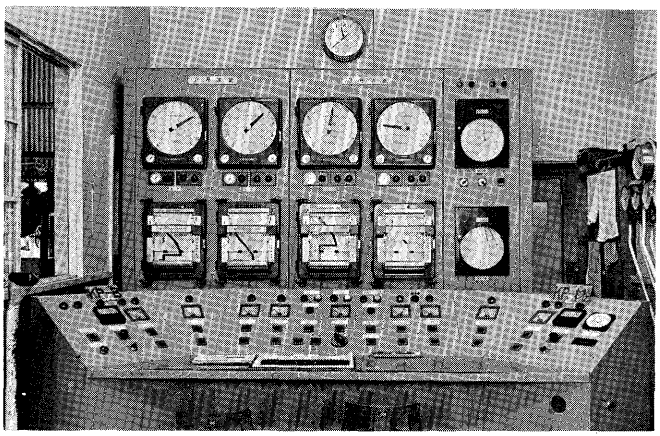

Fig. 8 Instrument panel

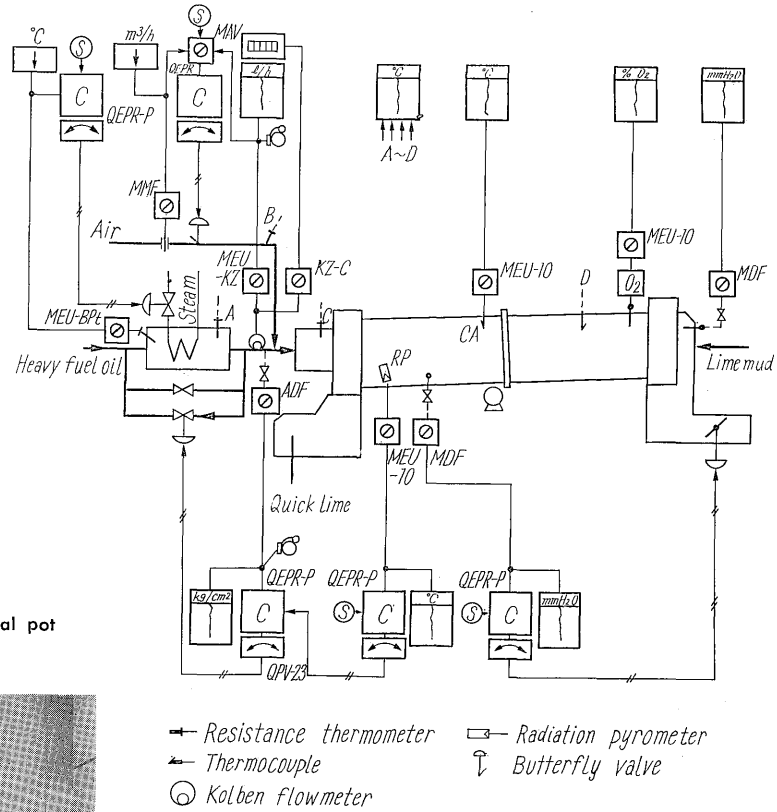

Fig. 9 Instrumentation diagram of CaO recovery kiln

pressure between the pressure at the top and the bottom of the digester; however, the transmitter and recorder are the same as those of a flowmeter.

3. Instrumentation of CaO Recovery Kiln

Fig. 9 shows a summary of the process and schematic diagram of the CaO recovery kiln. In this process, the lime mud (formed when the green liquor from the digester's waste solution is recovered as a white liquor by adding quick lime in the caustification process) is calcinated and recovered as quick lime for use in the caustification process. Therefore, even though this process is not regarded as functionary in a pulp plant, it has many aspects that are different from those of other processes in regard to instrumentation. For instance, because of outdoor installation of a kiln and its ever-present dust, most of the transmitters used are electric. In this example, all the transmitting signals are unified with TELEPERM signals. The main control systems for this process: the controlling of burning temperature, controlling of mixing ratio of air and the heavy fuel oil, controlling the furnace and draft and controlling of the uniformity of the lime recovered.

1) Instrumentation for temperature control

The temperature of the burning zone is detected by a radiation pyrometer. Since the detected value contains a lot of high frequency noise, it is filtered before it is transduced into TELEPERM signal by an electric transducer (MEU-10). It is then cascaded to the fuel oil injection pressure controller (QEPR) through the electro-pneumatic controller (QEPR). Since the controller (QEPR) has electric measuring input and pneumatic setting, a cascade control is easily obtained by a dual connection. If an operating device (QPV-23) for cascade control is used, either cascade control or fixed value control can be easily performed by a change-over from one to the other. Because of a unit system, the operating device is separated and can be used in any combination. This is a definite advantage. The heavy oil pressure is detected by an "Apgrif" pressure transmitter (ADF) and is transmitted in the form of TELEPERM signal. The transducer of the radiation pyrometer is a burn-out type and issues a signal to the controller when a burn-out of a thermocouple occurs. Of course, a warning signal is issued at the same time. In the case of the burner injection pressure, a warning signal is issued when the pressure drops below a limiting point to ensure an accurate fuel supply. The detecting of the kiln center temperature is important because this imparts the knowledge of temperature distribution inside the kiln; a slip ring mechanism and its associated thermocouple are used for this temperature detection. In temperature detection using a slip ring mechanism, the temperature indication swings according to the position of the thermocouple during its rotation. For this reason, it is better to distribute 2∼4 thermocouples over the kiln's outer circumference and record the average value from them.

2) Instrumentation for pressure controlling

For proper burning, it is necessary to control the kiln's front draft. A TELEPERM slight pressure transmitter (MDF) is used for detection; the draft is controlled through electro-pneumatic controller (QEPR) by pneumatically operating the kiln exhaust gas damper. The draft detecting section is shown in *Fig. 10.* The heavy oil pressure control has already been explained; the controlling is done by a control valve in the return circuit.

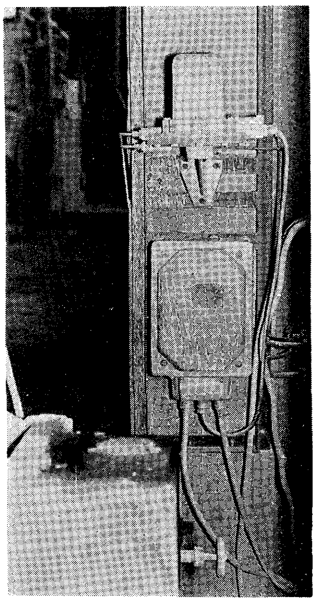

Fig. 10 TELEPERM pressure transmitter

3) Instrumentation of flow controlling

The heavy oil flow is measured by a "Kolben" flowmeter (KZ-3 E-10), current transduced by an electric transducer (MEU-KZ) and is used for recording and as a signal for fuel-air ratio control. For integrating the flow quantity, the number of the pulses transmitted by the transmitter is used directly for integrating because of this method's high transmission accuracy. The air flow is measured by a TELEPERM flow transmitter (MMF). In this transmitter, since the square calculating is done in its electric circuit, the transmission current is in a linear relationship to the flow. For this reason, this transmitter is well suited for ratio controlling. In this example, the TELEPERM electric signals for the heavy oil and air flows are calculated proportionately by a differential amplifier (MAV) to control the air side damper opening by means of an electro-pneumatic controller (QEPR). Thus this is a logical method in which calculating is done electrically and operating is done pneumatically.

As shown above, in the instrumentation of an outdoor kiln involving difficulties in the piping of the air circuit, the following have been standardized: electrical transmission of all measured signals, controllers used are the electro-pneumatic controllers (QEPR), all electro-pneumatic transducing done within the controllers and operating ends are pneumatic.

V. CONCLUSION

The instrumentation for a paper-pulp plant has been described by using a few examples. Besides the above, there are many instances in which TELEPERM-TELEPNEU system has been used, and many examples of radio isotope instruments and data loggers; lack of space prevents mentioning them at this time. As can be seen in the above examples, the TELEPERM-TELEPNEU system based on a unit system is very versatile and can be used in a variety of combinations pneumatically and electro-pneumatically. For these reasons, the TELEPERM-TELEPNEU system will be used more extensively in the future in the instrumentation of paper-pulp plants.