"Pulsed infrared light used to continuously measure pulp consistency"

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SUMMARY

Optical systems are here to stay as a means of measuring consistency in pulp and paper mills They have to be calibrated for each application and are presently not recommended for systems containing significant amount of fillers. The Cerlic Consistency Meter Type ACM using pulsed IR transmitted light makes it possible to measure over a consistency range of .005 to 4%. This enormous flexibility, combined with full control of measuring range and sensitivity, makes it an ideal system for the pulp and paper industry. It will allow existing mechanical systems to be replaced because of better and more reliable performance. In addition, it allows the measurement of consistencies of below 2%, which thus makes it possible to control processes such as screening cleaning, thickening headbox operation and retention, save-all and filter operations white and green liquor particulates, and effluent operations.

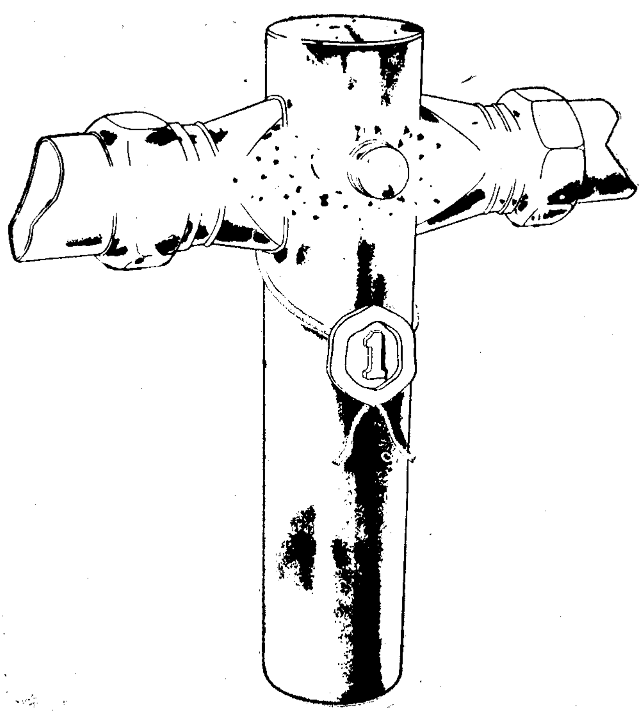

Fig. 1

This paper deals with the Cerlic Consistency Meter Type ACM, reviewed mainly from a process standpoint. The paper will compare mechanical and optical systems, discuss the particular advantages of the Cerlic systems as compared to other optical systems, and review applications.

The measurements and control of consistency, that is, the weight of fibres per volume of fibre suspension, is critical to the pulp and paper industry. It is necessary in order to control the mass flow of fibres, additives, etc. to the different processes in these systems. Measurement of consistency becomes more complicated by the fact that fibre suspensions are heterogeneous mixtures of fibre of different sizes and shapes, including very small particles such as fines and fillers. Particle size can thus vary from 3 to 5 mm with a slenderness ratio of between 100 to 200 to filler particles of less than 1 micron. At the moment, there are no direct methods available for measuring consistency and we therefore must use indirect methods. That is, we must measure physical properties of the fibre suspension that more or less correlate well with the consistency.

1. Mechanical Systems :

Presently, the mechanical methods completely

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dominate the field of consistency measurement. In such systems, stationary or rotating blades or bodies are used to measure the fibre network strength of the fiber suspension. Fibre network strength is a function of consistency, but is also very dependent on the properties of the fibers, especially their length, slenderness and stiffness. The fibre net-work strength results from the mechanical interaction between fibers and is very much dominated by the long fibres in the fibre suspensions. Small particles, fines, and fillers have a minimal effect on the fibre network strength. Mechanical consistency measurement systems therefore preferentially measure the long fiber content in any fibre suspension. Because of the impact of mainly the fiber size distribution on the relationship between consistency and fibre network strength, it is necessary to calibrate the consistency meters for each pulp In addition, the mechanical forces become very small at low consistencies, which makes mechanical consistency measurement and control really useful between only 2 to 6%. Below about 2%, they do not work. Mechanical systems are therefore not applicable to a number of processes in the pulp and paper mills, such as screening, centricleaning, headbox systems, side hill screens, and fines and filler containing systems such as are found in the white water from paper machines, save-alls. filters, and effluents including sludge and white and green liquor. As indicated, mechanical consistency meters cannot be used on non-fibrous systems such as white water systems, effluent, and white and green liquors, to mention a few. In addition, the mechanical systems are sensitive to flow rates, that is, the velocity of the fibre suspension, freeness, and temperature. On the other hand, the mechanical systems are not sensitive to fines and therefore measure long fibre consistency.

The mechanical systems normally have moveable parts and are therefore difficult to keep in operation and calibration, which reduces their accuracy and reliability. They need considerable maintenance to perform reasonably well.

The industry is therefore expressing an urgent need for better and more reliable and versatile consistency measurement and control systems.

2. Optical Systems :

Another way of measuring consistency is to measure the optical density of the fibre systems. This method is becoming increasingly attractive and a number of systems are now in use that can do this. Optical systems have been tried since the 1940s without much success, but new technology is now making it possible to use these system based on either reflected or transmitted light.

The optical systems do not measure the consistency as such, but measure the optical density of the fibre suspension is dependent on the absorption and scattering of light, it depends on the absorbative properties, the refractive index, and the amount of optical surfaces in the suspension. As small particles have much higher surface area per unit weight than do larger particles they also have a much larger optical density. Thus, in systems with a mixture of larger fibres, smaller fibers, fines, and fillers, the smaller particles have a much larger effect on the optical density. This means that each type of pulp must be individually calibrated, as they must also be with the mechanical consisteney measurement systems It also means that the optical systems preferentially measure fine materials, while the mechanical systems are more dependant on the long fibre fraction. However, based on experience from Cerlic that have over 100 of these systems in operation, this is not critical for the fibre distribution variations normally encountered in pulp and paper mill systems. Normal freeness variations of the mechanical pulp in, e.g., newsprint mills, do not affect consistency enough to be of concern. Switching between different pulps will necessitate separate calibration curves. However, it is possible to switch calibration electronically without any difficulty.

The only major limitation of optical consistency metres seems to be with regard to fillers that have such a high refractive index that they dominate the optical density of the fibre suspensions. In fibre systems with fillers, the optical density is basically determined by the filler content. In the future, it might be possible to modify the optical systems to differentiate between fillers and pulps.

Despite this limitation, the optical systems have many advantages over mechanical systems. Based on today's teconology, it is possible to measure fibre consistencies up to at least 4% and in some instances, higher. At the same time, it is possible to measure particle suspensions down to almost o with the same meter. The measurements are flow and temperature independent. As the optical systems have no moving parts, they are simple, reliable, and accurate, The ability to measure over the full consistency range down to very low consistencies makes it possible to measure and control consistency in operations and processes that have been outside that of the mechanical systems. The optical system thus have a definite place in all processes where the consistency of particle suspensions is measured.

3. Advantages of the Cerlic System

There are two major principles used in optical consistency meters. Most systems measure reflected light and only the Cerlic system measures transmitted light. To use *transmitted light*, it is necessary to have a very intense light source and this is the key to the Cerlic consistency Meter Type ACM.

3.1 Transmitted Light

As shown in Figure 2, Cerlic uses a measuring cell which has 2" diameter connections and then is changed to a rectangular channel with a depth of 20 mm, which is the distance between the IR light diode and the detector. The design of this particular cell is such that it creates turbulent flow conditions which keep the optical surfaces clean. Over 100 of these cells are now in operation and there has been no problem with dirt on the optical surface. In one case, where the mechanical meters had to be cleaned very often because of pitch deposits, no such problems have been experienced with the Cerlic meter. The use of transmitted light makes it possible to measure under more defined conditions. As the meter is positioned in a bypass as shown in Figure 3, the flow velocity through the meter can be independently controlled, which is important in order to control the measuring conditions and prevent fouling of the optical surfaces. This alio means that boundary layer conditions do not affect the measurements. This can be a serious problem for gauges based on reflected light. In addition it is very easy to sample exactly the same pulp that is passing through the meter, which is necessary for a good calibration. A correct installation of the sampling line is necessary to ensure a representative sample and to keep dead time to a minimum. Following Cerlic's *recommendations*, this is not a problem. Presently, Cerlic limits the maximum consistency to 4%, due to potential problems with sampling above this consistency. The bypass installation also makes the meter very easy to install and maintain.

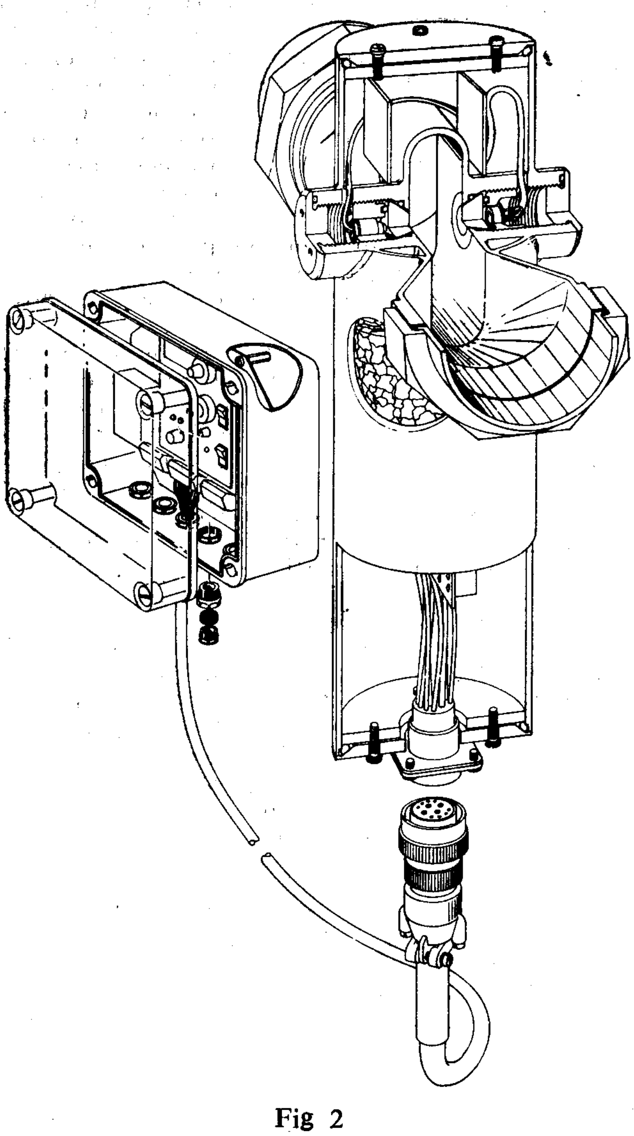


Fig 2

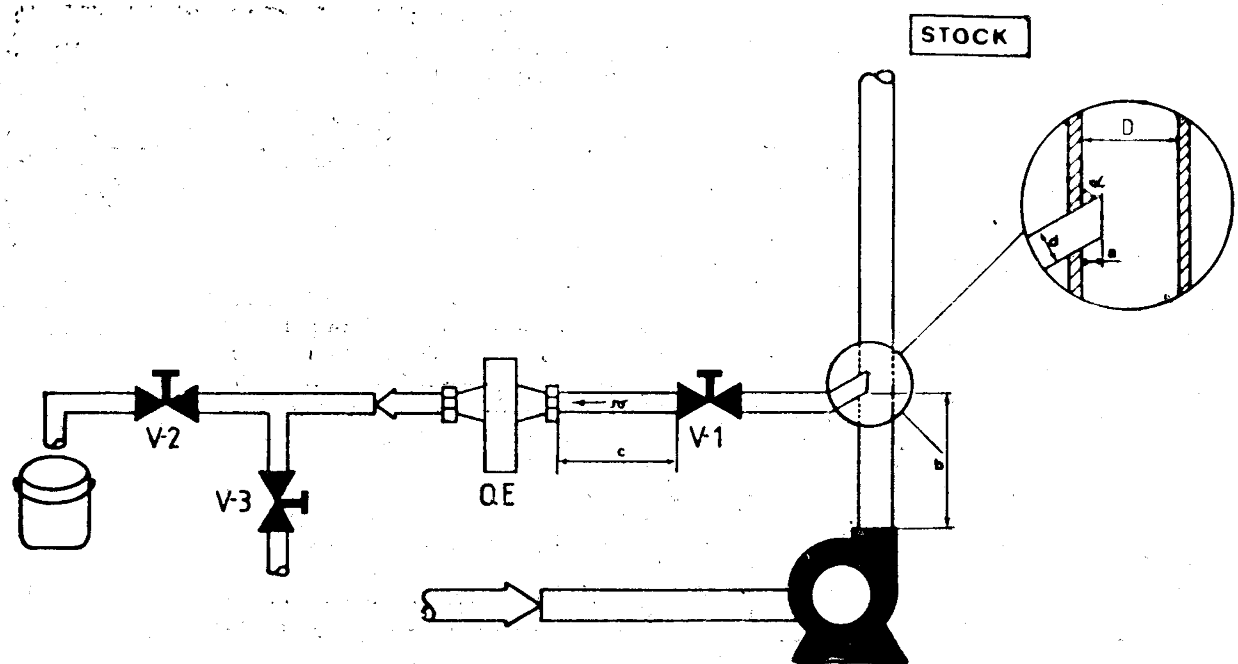
The meter is also less dependent on variation in the relationship between absorption and refraction of the fibre suspensions, as one is always measuring across a fixed distance. This is not the case for reflective gauges. Transmitted light ensures that the results follow *Lambert - Berr's Law* (Figure 4) and makes it possible to measure down to very low consistencies. This is why the Cerlic meter can measure from .005% to 4% with the same measuring cell.

3 2 Pulsed Light

The key to measuring in transmitted light is a *very high intensity light source*. The Cerlic Consistency Meter Type ACM uses pulsed light with a pulse length of 8 milliseconds and 20 pulses/second. This means that the energy is on only 16% of the time. This allows very high intensity to be used without overheating the system or having to put in cooling. Electronically, the Cerlic meter can vary the sensitivity or the amplification from 1 to 1000, which allows measurements from .005 to 4 % in consistency.

3.3 IR Light

The light source emits IR light with a 950 nm wavelength, which is equal to .95 microns. The infrared light at this wavelength makes the meter *insensitive to colour*. There are no substances known up to now in the pulp and paper systems that will absorb this radiation. In addition, water and glass have no absorption at this part of the spectrum. This means that the system is *independent of*, for instance, black liquor and other *colors present in pulp and paper systems*. As far as refraction and



Fig, 3

LAMBERT - BEER'S LAW

$$I = I_0 \cdot E^{-K \cdot C \cdot D}$$

I_0 = LIGHT SOURCE INTENSITY

I = MEASURED INTENSITY

K = ABSORPTION COEFFICIENT

C = CONCENTRATION

D = THICKNESS THROUGH WHICH THE LIGHT IS TRANSMITTED

Fig. 4

scattering, the IR source will behave about the same as for light for size particles that are present. The IR light makes this meter applicable to unbleached systems with black lipuor, effluent systems, and other coloured systems in addition to uncoloured ones.

3.4 Electronic Processing Unit

Figure 5 shows a schematic diagram of the electronics of the Cerlic ACM Consistency Meter. The meter is *temperature compensated* by having a measuring circuit and refrence circuit in parallel. The reference circuit that uses air keeps the light intensity constant. It also takes care of the effect of temperature on measurement and thus gives automatic temperature compensation. The meter has four different measuring ranges, with 1, 10, 100 and 1000 amplification. In addition, one can measure in a *linear* or in a *logarithmic* mode. This is shown in Figure 6. In addition, it is possiblis to change the minimum point and the scale within each measuring range. This gives this tool enormous flexibility. One can either measure with very high sensitivity over a small range, as shown in Figure 7, or over a very large range with less sensitivity, as shown in Figure 8. Figures 7 and 8 also show the excellent straight line relationship between measured consistency and the display. The Cerlic Consistency Meter Type ACM therefore makes it possible to measure over a very wide measuring range while controlling the desired range and sensitivity. One and the same piece of equipment can thus be used for measuring effluents at .005 consistency and fiber consistency at 4%.

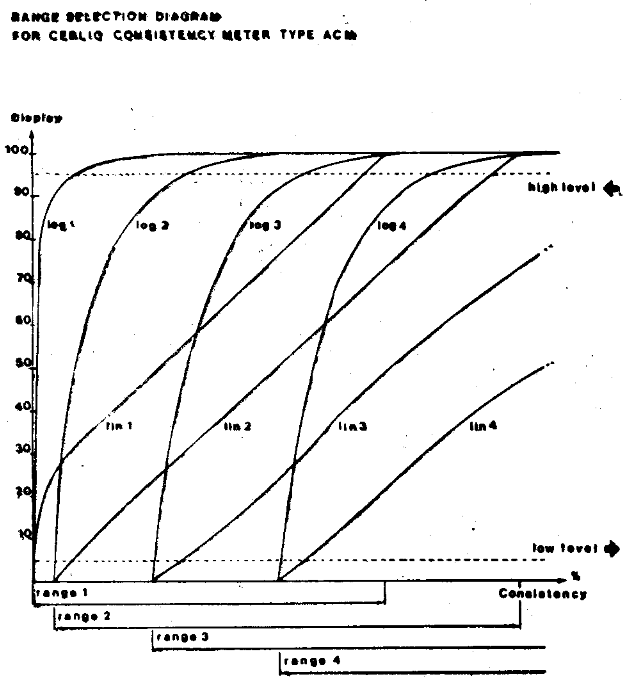


Fig. 5

3.5 Testing

The Cerlic Consistency Meter Type ACM will be tested shortly by Inst. Paper Chem (IPC) in their consistency testing loop. About 100 commercial installations are presently in operation worldwide. The first installation was made in 1981.

4. Applications

The Cerlic Consistency Meter Type ACM can measure any suspended particulate matter including pulps that have an optical density below a certain level set by the intensity of the probe. So far, this limit seems to correspond to a pulp consistency of about 6%. It is thus a universal tool for measuring and controlling consistency in pulp and paper mills, but also in other process industries Its main applications in the pulp and paper industry are :

4.1 To replace mechanical meters wherever used becausc of higher reliability and accuracy.

4.2 To permit consistency measurement in areas where mechanical consistency meters cannot be

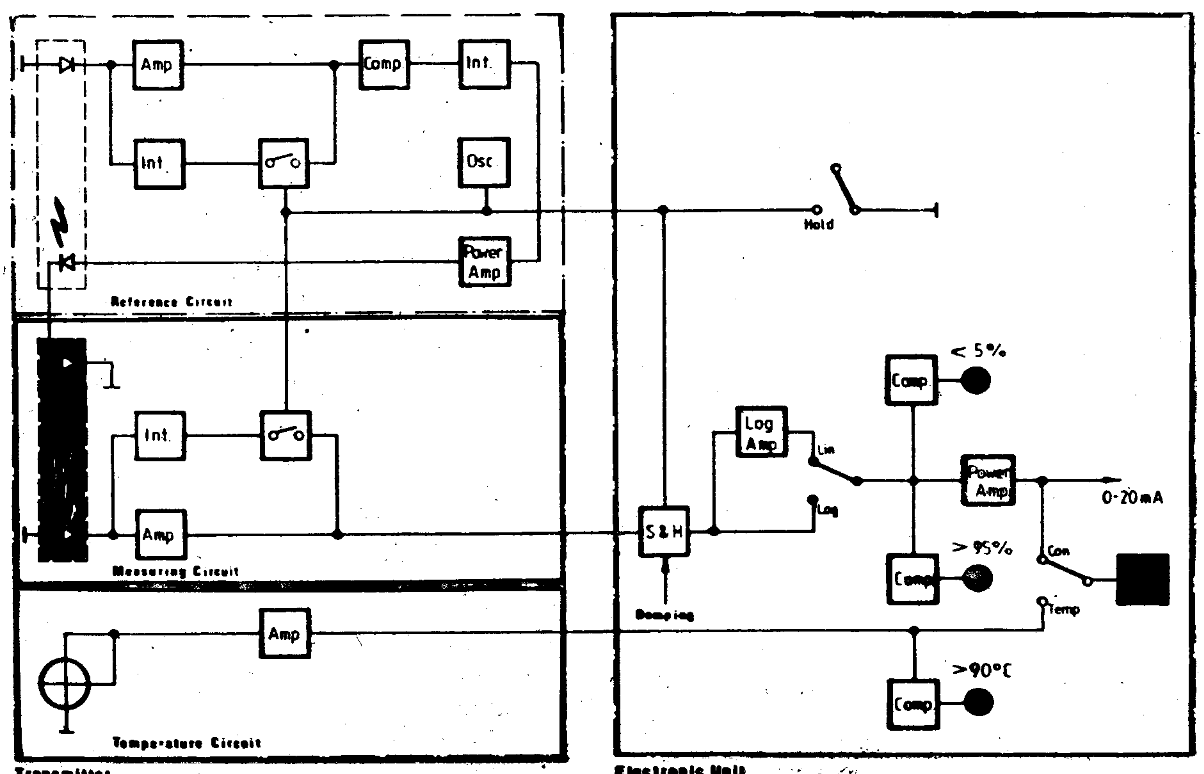


Fig. 6

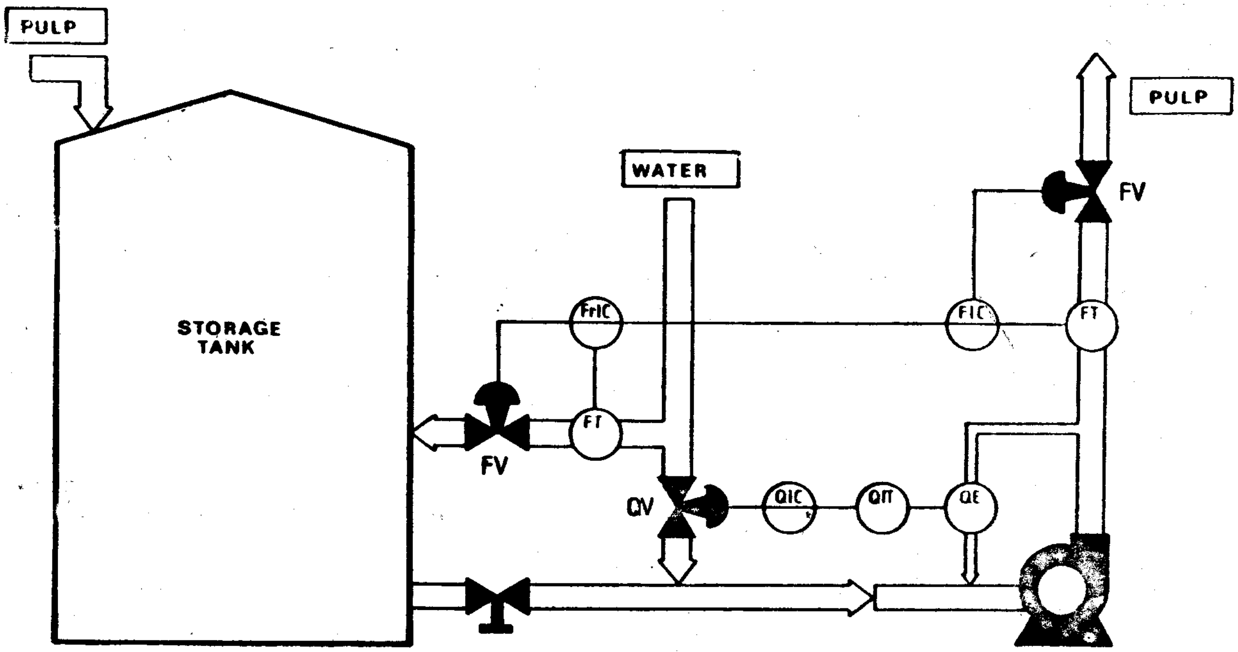


Fig. 7

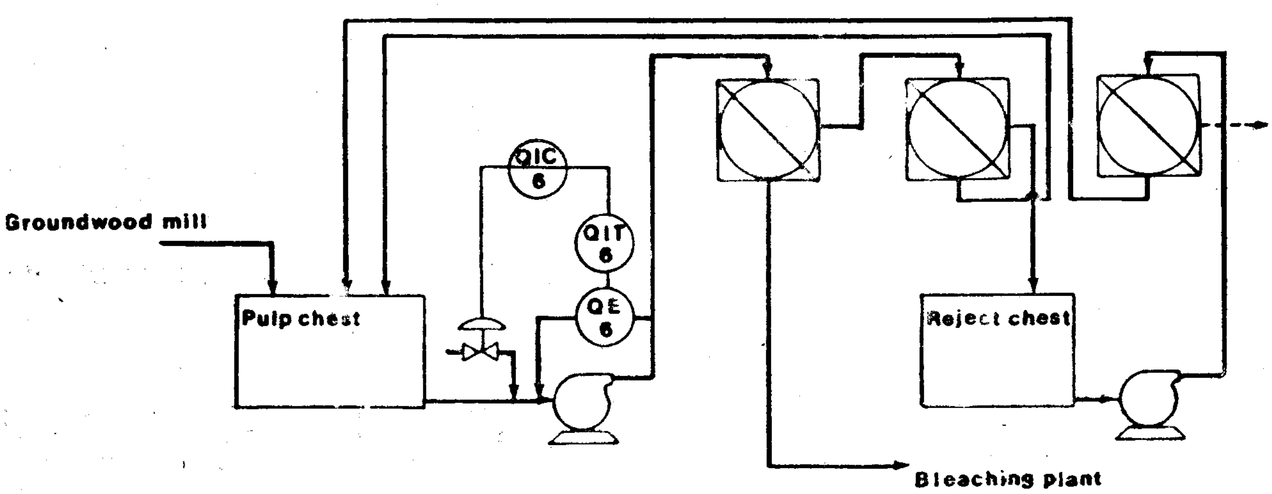


Fig. 8

used and where need for consistency measurements exist.

4.2.1 Screening

It is very important to have control over the screening operation in order to control the cleanliness of the accepted pulp and the conditions of the entering pulp. Consistency measurement of accept and reject streams are therefore very attractive. Many installations are found in, e. g., groundwood and TMP plants.

4.2.2 Centricleaning

The same argument applies to centricleaning as to screening.

4.2.3 Side Hill Screens

As above.

Headbox

The headbox consistency, especially if combined with measurement of the white water consistency, is of great importance to the paper

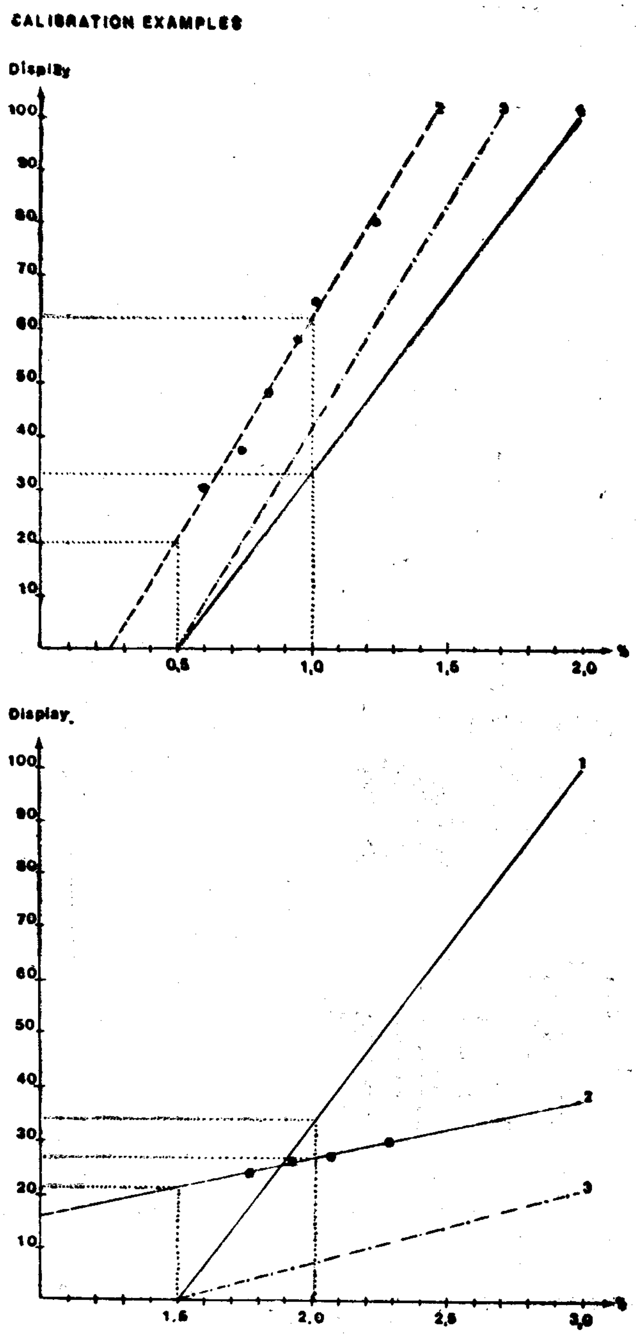


Fig. 9

machine operator. By measuring the headbox and the white water consistencies, it is possible to measure retention and thus the operaton of the wet end, the wet end chemistry, and ingoing pulp quality. In systems with fillers, measurements of white water consistency alone can be used to control filler retention.

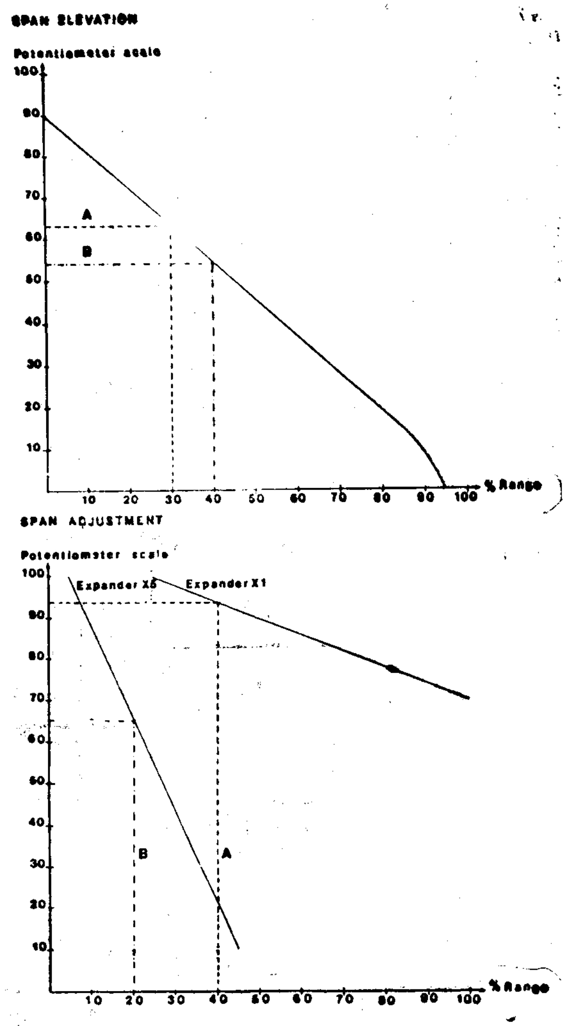


Fig. 10

Save-alls

Consistency measurement around the save-alls will allow improved operation and control over the quality of the cloudy and clean water.

Filters

This consisteney meter allows measurement of ingoing consistency and water consistency to and from filters.

Effluents Including Sludge

The Cerlic Consistency Meter Type ACM makes it possible to measure solids in effluents and sludge. Its insensitivity to colour and its flexibility makes it very attractive for these applications.

White and Green Liquor

These are also excellent applications in order to control the caustisizing process.