outside of the plant. It is so obviously true that good quantity and good quality make for economy of operation that it seems hardly necessary to make this final generalization. I am making it merely because we demonstrated to be a fact that it is more economical to operate a plant on a three shift basis than on two.

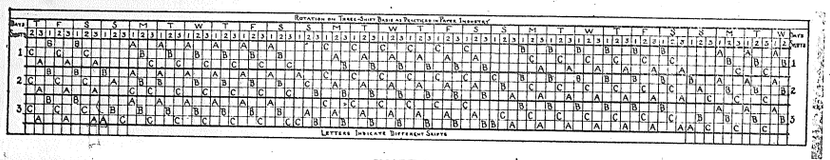

CHART B

Rotation of Shifts

Chart B shows three methods of rotating shifts, as it is ordinarily done in the paper industry. The letters indicate different crews, or shifts, and a complete period of rotation is shown. No. 1 indicates the method where there is no Sunday work. No. 2 indicates one way of changing the rotation in a seven day continuous process department, such as the boiler house, digester building, etc.; and No. 3 indicates an alternate way of changing shifts, which is frequently used.

It will be noted from this that the men are all on different shifts each week. This happens to be customary in the paper industry. The men, however, could remain two, three or four weeks on each shift, in fact there are one or two mills where the men remain two weeks on one shift before changing. I know of no instance, however, in the paper industry, where men remain constantly on the same shift. In the continuous process department where seven days a week are necessary, we make it a policy to encourage the men to lay off one day in seven.

A plan of operation in the maintenance department in a plant where we had approximately 300 men at work on construction and repairs, may be of interest. The maintenance and repair work in all paper mills is a big factor on Sunday, when the plant is down, especially in a mill that is being rebuilt, so it is necessary for a full crew to be on hand on Sundays. However, we found our men tiring out under the strain and devised a plan for practically raising the "time and one half" Sunday's pay to double time, only the extra time accumulated as a credit which the man could take off during the week at the company's expense. In other words, if a man worked all day Sunday he could take off half a day during the week, or he could allow his time to accumulate and take off a full day every two weeks.

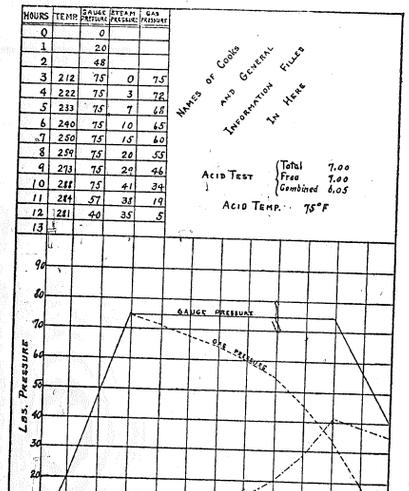

CHART C

Management Changes Required

One of the difficulties that will be encountered in any process that requires close attention is the greater variations which tend to develop when a larger number of men are at work. We had heard that the quality would vary more on three shifts than on two. However, we found that there was very little to this contention, as the greater alertness of the men, because of the shorter hours, offset the variations due to the increase in the number of persons controlling

the operations. However, simultaneously with the change to the three-shift basis we began keeping continuous records of performances, which enabled the workman to more readily visualize what had taken place before he came on. In this way he could more consciously carry on the process and so produce the least possible amount of variation in the product. What I mean by this is shown in Chart C, showing a cooking chart from our digesters. The heavy line is drawn to indicate the change of shifts. Obviously a cook coming on at the seventh hour would easily be able to control the process, knowing just what had taken place previously. A graphical visualization of this work is very important. This illustration is taken from a sulphite pulp mill and the following is a description of this operation, taken from a paper called "Non-Financial Incentives," which I read before the American Society of Mechanical Engineers, December, 1918:

This chart was designed to give the cook information about the reactions in the digesters in which the wood chips are cooked in a 6% solution of sulphurous acid partly combined with a lime base.

The digesters have a conical top and bottom and are usually 50 ft. high by 15 ft. in diameter. After the acid and chips are put into the digester and the cover is put on, steam is turned in at the bottom and the pressure brought up to 75 lbs. per sq. in. above atmospheric pressure.

As this does not heat the digester sufficiently to produce disintegration of the wood, it is necessary to relieve gas through a relief valve on the cover. Because of the removal of this gas, which is afterwards reclaimed, more steam can come in at the bottom and thus the temperatures are advanced. The skill in cooking consists in the proper control of the relief valve.

Before the introduction of these cooking charts illustrated by Chart C, all this was left to the unaided judgment of the cook, with usually nothing to help him but a small hand thermometer and a pressure gauge. Of course, great variation in the pulps was the result. The cooking charts, plotted by the cooks themselves, however, helped greatly as they enabled the quick visualization of the work. On these charts, temperatures are converted to pressures for the reason that the pressure in the digester comes from two sources, one the natural pressure due to steam, and the other due to the sulphurous acid gas. The pressure, for instance, which would correspond to a temperature of 212° would be 0 at atmospheric, yet from the chart you will see the gauge pressure actually showed 75 lbs. The difference between 0 and 75, therefore, is caused by the presence of sulphurous acid gas. As the cooking progresses, the gas is naturally used up; first, by being relieved for the purpose of making room for more steam; second, by the natural combination of the acid with the organic compounds liberated during the cooking process.

At the end of the cooking process the gauge and steam pressures will naturally come very close together as the greater part of the SO_2 gas has been used. The gas pressure curve is obtained by subtracting the steam pressure from the gauge pressure. It is really a resultant of the other two. If it drops too rapidly the cook knows that he is relieving his digester too hard and checks the opening of the relief valve. If it does not drop rapidly enough he knows he must open the valve wider in order to increase the relief. Of course, the figures are taken from recording instruments which are checked daily to insure accuracy. Naturally, an ideal cooking chart was soon formed, being the joint work of the cooks handling the digesters and of the chemical research department.

Immediately after the introduction of these charts a very marked increase in the uniformity of the pulp was noticed, and the cooks, while at first opposed to the new method of "cooking with a lead pencil" as they called it, soon learned to like their work, much better for the reason that they now had some way of visualizing the work in its entirety. In addition to more uniform quality of the pulp, the yield from a cord of wood increased something over five per cent.

We soon found that it was necessary to give some sort of continuous progress record if we were to keep up the interest in the work, because no man could carry in his mind anything but a general impression of his progress from day to day. Several good records for one day are only like so many good golf drives. They are a source of satisfaction at the time, but just as the score in golf denotes our real mastery of the game, so does the progress record measure the man's increasing mastery of his work, and we feel that it is one of the moral obligations of the management to keep such records for the individual workman. Without these records men will not think of improvements in the process and they cannot be blamed for becoming indifferent. How long, for instance, would a superintendent or manager retain his interest in the economical operation of his plant if his cost sheets were withheld? We, as executives, must have quantity, quality and economy records, otherwise our interest soon lags. Why, then, should we expect the workman to be interested when he is not furnished with a record which at least reflects one of these elements?

Referring to Table III, it will be noted that there are nine men cooking. These men are posted in the order of seniority, with the highest monthly record on top. There are three foremen at the top of the record. Each of these foremen has three cooks under him and their standing is made up by taking the average records of the men under them. In this way we are enabled to get not only the individual records of the men, but the group, or team-work records, as well. The lower group is merely for the convenience of the department head in charge and gives the relative standing of the large, medium, and small digesters. This is irrespective of the men who are working on them.

The total progress record figures in the first column are made up of the temperature, color, time and blowing records. The relative values that these have in the total record are shown at the top of each column, the total adding up to 100. The small variation in the monthly average column is characteristic of all our progress records, and shows how great is the incentive when individual effort is intelligently recorded.

The temperature record is obtained by taking half-hourly readings from the recording-thermometer chart, upon which a standard temperature curve has been plotted, calling each reading which happens to fall on the standard line 100, and a reading 20 deg. either side of the standard line 0. This means that for each degree off of the standard, 5 points are deducted from the progress record.

The color record indicates how near the men come to blowing the digester when the color of the liquor shows the proper amount of lignine in the solution. The sample, drawn from the side of the digester, is compared with the standard color. To get a methematical value for this factor a range of colors from a dark to a very light was obtained, the particular shade which was taken as standard marked 100 and one shade either side 10 points less than 100.

The time record is obtained by calling a certain time of cooking 100 and taking off on each digester cooked one point for each minute above or below this standard.

The blowing record is obtained by calling 30 lb. pressure 100 (most of the cooking being done at a pressure of 75 lb. per sq. in.) and 60 lb. 0, the idea being to get the pressure as low as possible before blowing the digester.

It will be noted that the temperature value is higher than any of the others. This is because it is the most important element. The color record coming next in importance is given the next highest value, etc.