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HANDLING OF TOTAL ORE IN A CCD THICKENER CIRCUIT

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The use of a series of thickeners for washing of the slime fraction of a leached ore is not uncommon in the uranium industry; however, few ore processing mills have used a thickener circuit for washing leached total ore. The common practice is to wash the sand fraction in classifiers and the slime fraction only in thickeners.

At the Uravan mill of Union Carbide Nuclear Company, a total ore acid leach is employed to extract uranium values from sandstone ores. These leached ores are then washed at a nominal rate of from 1,000 to 1,300 tons per day in a series of washing thickeners. A typical screen analysis of the ore being washed in these thickeners is 25 percent -200 mesh, 3 percent +35 mesh and about one percent +14 mesh. The amount of slimes (-200 mesh) will vary from 20 to 30 percent as the mill receives ore from 150 different mines. The washing liquor is acidic, from a pH of about 2 in the first thickener to 0.6 pH in the last thickener and of course all acid duty equipment must be used.

The Uravan mill of Union Carbide Nuclear Company is located in Montrose County, Colorado and is physically located on a canyon wall along the San Miguel river. The thickeners referred to in this paper are located on top of the mesa above the canyon. For purposes of identification, these thickeners are numbered 1 through 8 from south to north.

GENERAL DESCRIPTION OF CIRCUIT

The circuit utilized consists of eight 60-foot diameter by 12-foot deep wooden fir tanks set in a line and staggered in elevation by approximately 3 feet. The washing water flows through the thickeners by gravity while the ore pulp is pumped uphill from thickener to thickener. Adequate piping and pumping capacity are available such that any of the thickeners can be bypassed in the circuit. All the controls for the thickeners are located in a centralized control room and approximately 80 percent of one operator's time is used to operate this circuit.

EQUIPMENT

The drive mechanisms used for these thickeners are driven by 3-horsepower motors. The mechanism is of the non-lifting type, and a torque arm is employed in the drive to indicate overloads. A pointer is attached to the torque arm and the load on the thickener is indicated on a dial attached to the drive. Whenever 50 percent of the maximum allowable load on the thickener is attained, a mercoid switch actuates a warning light in the control room and when a pre-set maximum load is reached, another mercoid shuts off the drive. Normally the thickeners are operated at no load.

The rake mechanism consists of two long rake arms, extending the entire diameter of the thickeners and two shorter arms which extend only 2 or 3 feet from the centerwell. All of the rakes are constructed of 316 stainless steel. The long arms are hinged at the centerwell and will raise at the outer ends whenever a load accumulates in the thickener.

The centerwell of the thickeners are approximately 10 feet in diameter and 4 feet deep and a wooden launder is attached to the inside circumference of the well. The pulp feed to the thickener is fed into the launder which then overflows distributing the feed around the entire centerwell. A diagram of the thickener tank and rake mechanism is shown in Figure 1.

A flocculating agent is fed into the overflow of the previous thickener and the diluted mixture is directed into the centerwell through a single pipe. The overflow launders in the thickener encompass approximately 1/3 of the circumference of the thickener.

The underflow pumps used are 3-inch centrifugal pumps. These pumps are driven by 10-horsepower motors through a magnetic clutch which is used for automatically varying the pump speed. These pumps, along with all piping associated with the thickeners, are located beneath the thickeners in a tunnel that traverses the entire length of the thickener circuit.

Two methods of providing seal water to the pumps are used. The principal method and method that has been used in the past, is to pump thickener overflow liquor with centrifugal pumps from the Nos. 1, 3, 5, and 7 thickeners to each of the underflow pumps. Overflow liquor from No. 1 thickener is used for sealing the pumps under Nos. 1 and 2 thickeners, liquor from No. 3 is used for the Nos. 3 and 4 pumps and so on down the circuit. An alternate source of mill water is also provided for cases where the overflow of the thickener is not clear. The second method employed for pump sealing is the use of mill water only, fed at a controlled rate through a control system to a modified packing gland. Originally, it was necessary to use thickener overflow for sealing the pumps. With the original packing glands rather large quantities of water (in the range of 20 to 30 gpm) were required due to large clearances between the packing gland housing and the pump shaft. Of course if mill water instead of thickener overflow had been used, washing efficiencies would have been seriously reduced. A modified gland is now available that has considerably less clearance between the gland and shaft and seal water rates of less than one gallon per minute can be used satisfactorily. The latter system has proven desirable and we are presently converting all of the underflow pumps to this system. The advantages of the latter system are: 1) no acid duty seal water pumps are required: 2) an increase in capacity of the underflow pump is achieved; 3) no concern arises with dirty thickener overflows, and 4) a more reliable, steady supply of clear sealing water is provided by the controller.

All of the piping used in the thickener underflow is rubber-lined, whereas plastic piping is utilized for the overflow liquor. A schematic diagram of the piping and control system used is shown in Figure 2.

CONTROL OF CIRCUIT

To achieve maximum washing efficiencies in a thickener washing circuit, it is of course necessary to achieve maximum thickener underflow densities. The normal operating underflow specific gravity of the total ore thickeners at Uravan is 1.53 to 1.55 with an ore that has a true density of about 2.6. The underflow at these conditions contains approximately 56 to 58 percent solids. The thickeners have been operated consistently at 60 to 62 percent solids in this circuit; however, at these conditions there is a tendency for the thickeners to backlog or build up excessive loads and islands, thus requiring considerably more operator attention.

An automatic centralized control system is utilized to maintain and control the thickener underflow densities. This system consists of a sensing device attached to the underflow pipe which senses the density of the underflow pulp. A signal is transmitted to a control circuit which varies the underflow pump speed to maintain a set density. The sensing device used consists of a Cesium 137 50 millicurie source that transmits gamma rays through the underflow pipe and in turn the underflow pulp. An ion chamber detects the quantity of gamma rays passing through the pipe and pulp and as is well known the amount of shielding, or absorption of gamma rays, is proportional to the density of the material. Consequently, the amount of gamma rays measured by the ion chamber is proportional to the density of the underflow pulp as the absorption by the pipe is constant. The measured signal is fed through an amplifier to an electronic recorder-controller. The signal, or indicated density, is recorded and compared by the controller to a set point, and a signal is produced which is proportional to the difference between the input signal and the set value. This signal is transmitted through a controller to the magnetic clutch on the underflow pump which increases or decreases the speed of the pump as necessary. A pre-set minimum pump speed of about 650 rpm has been established to insure there is always flow from the thickener underflow to prevent sanding of the underflow piping. Manual density measurements are taken every two hours at the pump inlet to check the calibration of the instruments. An experienced operator can detect from the type pattern obtained on the density recorder charts if good settling is being achieved in the thickener. A distinctly different pattern is obtained if the underflow pump is primarily sand, slimes, or a uniform mixture.

FLOCCULATION

A phenomena which occurs in a thickener used for washing total ore, that is somewhat different than when only slimes are fed, is that the coarse ore sand fraction will fall directly to the bottom of the thickener or ducks nest, whereas the slimes will distribute throughout the entire area of the thickener. An important feature in attaining good operation is to maintain a uniform settling rate of the slime fraction or a classification will occur and the thickener underflow will alternately consist of slimes and then sands. We have found that to obtain a uniform mixture of sands and slimes in the thickener underflow we must keep the slime level in the thickener at the bottom of the thickener tank. If non-uniform underflow mixtures are obtained, density control is extremely difficult because of the different compaction densities achievable with sands and slimes.

It is of course necessary to utilize a flocculent to control the settling rate of the slime fraction. We are currently using polyacrylamide type flocculents to aid the settling in the thickeners.

The flocculent is prepared at a strength of about 0.10 weight percent. This solution is fed from a head tank through a piping manifold to the thickeners and then introduced into the overflow of each thickener through pipe cap orifices. The solution is further diluted by the thickener overflow to about 5 ppm and then fed directly into the centerwell of the following thickener.

The pulp feed to the thickener is introduced in the launder previously mentioned which in turn overflows gently into the centerwell. This method of feeding results in a gentle mixing of the pulp feed and flocculent solution in the centerwell where the flocs of slimes form and the sand falls freely in an evenly distributed pattern.

Two methods of automatic control are used to regulate the quantity of flocculent fed to the thickeners. The primary method, which is used on the majority of the thickeners, is based upon the rate of pulp feed to the thickener. In this case, two feed streams of flocculent are fed through orifices. One of these streams can be turned off or on by a solenoid valve. The solenoid valve is actuated by an electrical circuit in the underflow pump speed control circuit on the previous thickener. Whenever the pump speed and the pulp flow increases above a set value, the second orifice is opened. Prior to installing this method of control, it was necessary to feed sufficient flocculent at all times to insure that the slimes would settle at the maximum pumping rates. Consequently, when the previous thickener underflow pump decreases in speed, an excess of flocculent was added. Installation of this semi-automatic feed system reduced our flocculent usage about 20 percent. We hope to decrease the usage further by replacing the solenoid valve with a control valve that will proportion the flocculent feed as determined by the previous thickener underflow pump speed. An additional manual method of control, which augments the automatic system, is changing of orifice sizes. The thickener operator manually measures the slime level in the thickeners every two hours with a transparent dip tube. The operator will then change orifice size to insure adequate settling is occurring but will use the minimum sized orifice to achieve settling. This is necessary as the ratio of slimes and sands in the pulp will vary considerably.

The second automatic method employed for adding flocculent is utilized on the No. 8 thickener which is fed with a constant speed pump from the leach circuit. This system utilizes a method of automatically monitoring the slime depth in the thickener and using this measurement to actuate a solenoid valve on the flocculent feed. The slime sensing device consists of two bubble tubes submerged in the thickener at two levels. The pressure difference between the bubble tubes is measured and as the slime level in the thickener moves up and down between the lower extremities of the tubes, a difference in density is detected as a pressure differential. The pressure differential is measured with a pneumatic transmitter and whenever the differential reaches a pre-set point, the solenoid valve on the second flocculent feed orifice is opened or closed. Utilizing this device also resulted in a reduction in flocculent usage of about 20 percent. In this case also, we are investigating the possibility of utilizing strictly proportional control of flocculent feeding through a control valve.

With regards to total flocculent usage, we are currently achieving a usage of about 0.16 to 0.18 pound per ton of ore processed in the eight thickeners.

WATER CONTROL

The CCD circuit operates on a 1:1 wash ratio, i.e., one ton of wash water is used per ton of ore processed. Water is obtained from two sources; fresh mill water and return water from the tailings area. Clarified river water and return water from the tailings dam are pumped to a storage tank and fed into the washing circuit by gravity. The flow is controlled by a conventional orifice, recorder-controller, control valve arrangement. The recorder-controller is located in the control room. The water system is relatively maintenance free as a periodic check on the calibration of the control circuit is all that is required. The flocculent for No. 1 thickener is comingled with the wash water as it is added to this thickener. The amount of water added by the flocculent streams is about 5 percent of the net water rate down the circuit.

OPERATIONAL FEATURES

The washing efficiency of the circuit approaches theoretical performance indicating that the method of contacting pulp and wash water is adequate. A typical profile of concentration and pH is presented in Table I. Little or no leaching of uranium is obtained in the thickener circuit.

Table I

PROFILE OF U_3O_8 CONCENTRATION AND PH OF WASH CIRCUIT

Thickener No.	% U_3O_8	PH
1	.0018	2.00
2	.0038	1.80
3	.0078	1.70
4	.0173	1.50
5	.0339	1.25
6	.0522	1.00
7	.1080	0.80
8	.2000	0.60

Uranium losses in the circuit are in the order of 100 to 200 pounds per month, primarily resulting from seepage losses at the tailings dam. As noted previously, the pH in the first thickener is approximately 2 so that no precipitation of uranium occurs. This pH level is natural to the system and no acid addition is necessary for pH control purposes.

The most common sources of trouble in the circuit are what have been termed "slime surges". These surges result from three sources: a) excess amount of slimes in the feed to the circuit; b) poor settling of slimes in a thickener causing the thickener to backlog slimes, and c) change of concentration of an impurity in the leach liquor which complexes the flocculent and reduces its effectiveness. In all cases, the trouble involves the slime fraction of the ore and the results are as follows:

a) The slimes do not settle satisfactorily and backlog in the thickener.

b) The sand fraction falling into the ducks nest will not contain the right proportion of slimes and thus pack to a density greater than normal.

Fortunately, these troubles are easily detected from a rise in slime level in the thickener as the operator makes his inspection trip over the thickener every two hours, or by a change in pattern on the chart of the recording density controller. The method used in correcting these problems is as follows:

a) Increase the amount of flocculent being added to the thickener by 10 to 20 percent. Although this will not help the slimes that are already backlogged, it insures that the slimes in the thickener feed will settle rapidly and will not add to the backlog.

b) Put the underflow pump on manual control and increase the speed to maximum in order to pump out the thickener. The density in the underflow will normally remain steady or increase as the sand bed is removed and then decrease indicating that slimes are also being removed. When the slime bed has been removed as indicated by manual measurements and a normal recorder chart, the density control can be returned to automatic.

c) The next thickener in the circuit will also show the surge but it is usually not necessary to increase flocculent rate or manually pump out the thickener as the automatic controls will handle the maximum input to the thickener.

It may take as long as eight hours to eliminate a large surge in a single thickener, so that if the surge occurs in No. 8 thickener, more than two days are required for the surge to pass through the system. The magnitude of the surge normally decreases as it moves up the circuit. The occurrence of surges this size are rare since they can be detected easily and cause no difficulty if caught early enough. It should be noted that the washing circuit routinely accepts 50 percent changes in solids feed rate with the operator needing only to change flocculent orifices in the interest of economy.

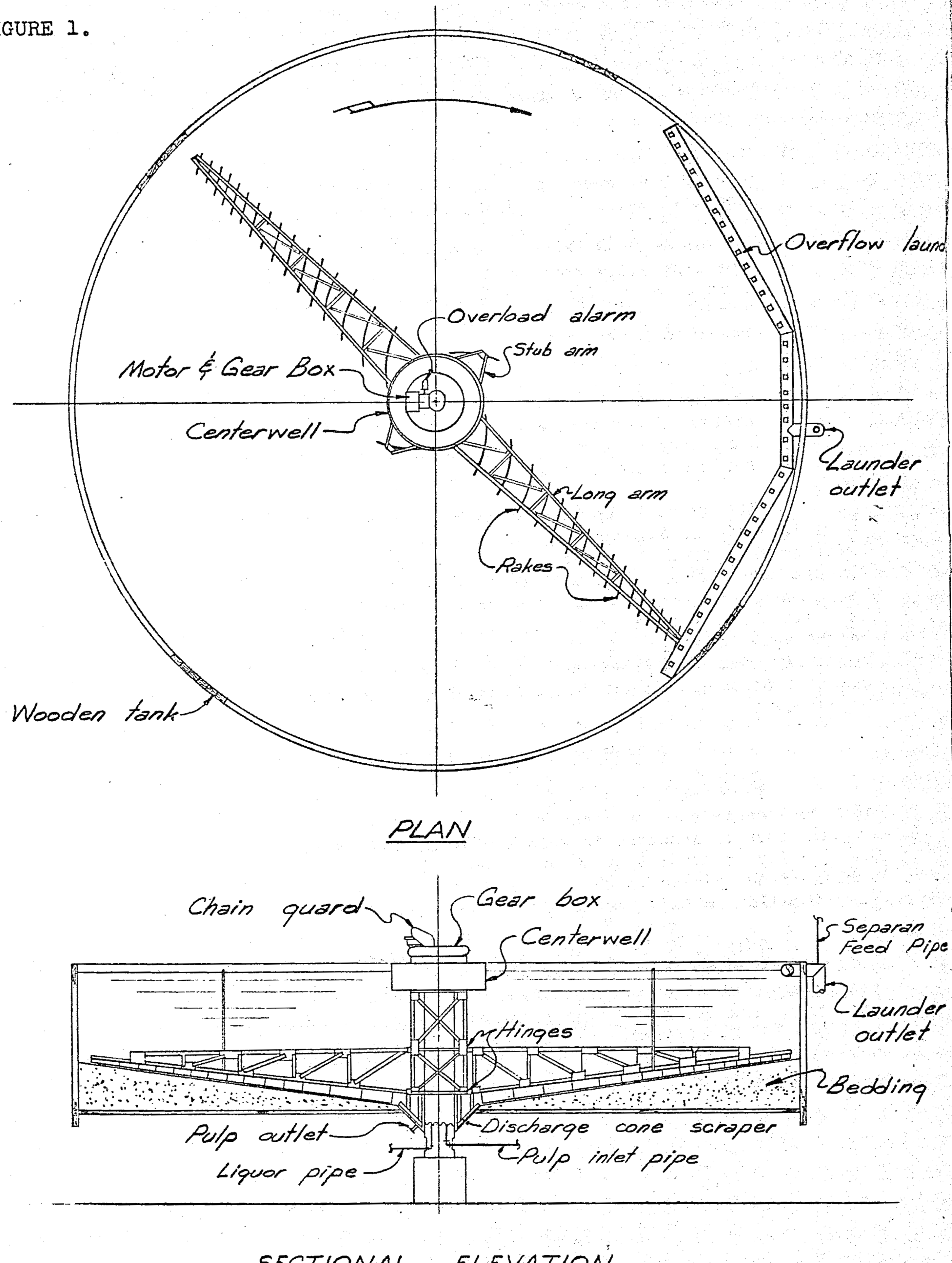
MAINTENANCE AND OPERATING COSTS

The maintenance costs experienced have been in the range of 5 to 7 cents per ton processed through the circuit. The majority of this cost is incurred in maintaining the underflow pumps, piping, and density control instruments. Abrasion of pump impellers and rubber-lined piping is the major problem. The average life of a pump impeller in this service is in the range of six months.

Other than reagents, which were previously discussed, the primary operating cost is operating labor and power. As mentioned previously, about 80 percent of one operator's time is used for operation of the circuit. The total connected horsepower in the circuit is 100 horsepower, not including the seal water pumps. The power cost will depend of course upon prevailing power rates at a given location.

Schematic Drawing of a Thickener

FIGURE 1.



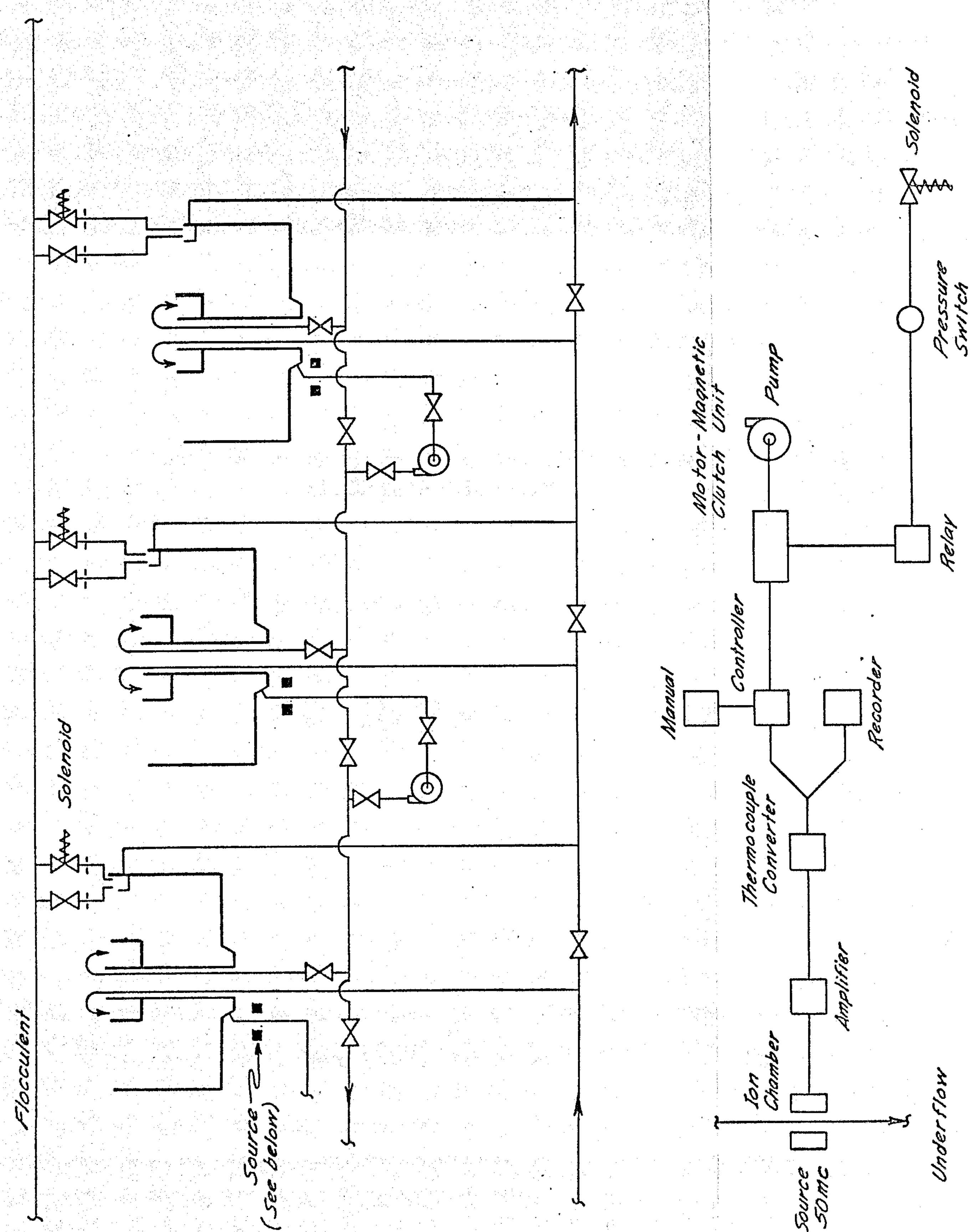


Figure 2 FLOW SCHEMATIC & INSTRUMENTATION