PRELIMINARY CONTROL TECHNOLOGY ASSESSMENT

OF

Amax Lead Company of Missouri
Buick, Missouri

SURVEY CONDUCTED BY:
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REPORT WRITTEN BY:
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NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
Division of Physical Sciences and Engineering
Engineering Control Technology Branch
4676 Columbia Parkway
Cincinnati, Ohio 45226

PLACE VISITED:	Amax Lead Company of Missouri Buick, Missouri
DATE OF VISIT:	August 6, 1981
PERSONS CONDUCTING SURVEY:	Frank W. Godbey Thomas C. Cooper
COMPANY REPRESENTATIVES CONTACTED:	Mike Kearney, Safety Director Terry Perkins, Mill Superintendent
PURPOSE OF SURVEY:	To investigate Amax's methods of controlling potential health hazards in the beneficiation of lead ore and to determine the advisability of conducting an indepth survey of this plant.

INTRODUCTION

The Engineering Control Technology Branch of the Division of Physical Sciences and Engineering, NIOSH, is conducting a research study to assess and document control methods for minimizing worker exposure to harmful substances, operations, and processes in the beneficiation of galena and cerussite (lead) ore industry. Exposure to a number of substances used in the beneficiation of lead ore may lead to a variety of health problems. These substances include lead, silica, nuisance dusts, and flotation reagents.

This preliminary survey was conducted to obtain information on control technology used in the industry including engineering controls, monitoring devices, work practices and protective equipment, and to determine the advisability of conducting an indepth survey of this plant.

PLANT DESCRIPTION

The Amax Lead Company's Buick Mine/Mill was discovered in 1960 and started production in 1969. The operation processes over 7,500 tons per day of a complex sulphide ore containing an average of nine percent lead. The mill operates seven days per week, 24 hours per day, with the exception of one shift per week used for maintenance of facilities and equipment. Of the total 450 employees at the Buick Operation, 50 are employed in the mill, and the remainder in the mine, office, and maintenance operations.

PROCESS DESCRIPTION

The ore beneficiation or mill process at the Amax Buick concentrator includes crushing and screening, grinding and classification, lead and zinc selective flotation, thickening, and dewatering. The basic components of the surface crushing and screening system are depicted on the flowsheet in Figure 1. The system consists primarily of two cone crushers with related screens operating in closed circuit with the necessary belts to handle the ore.

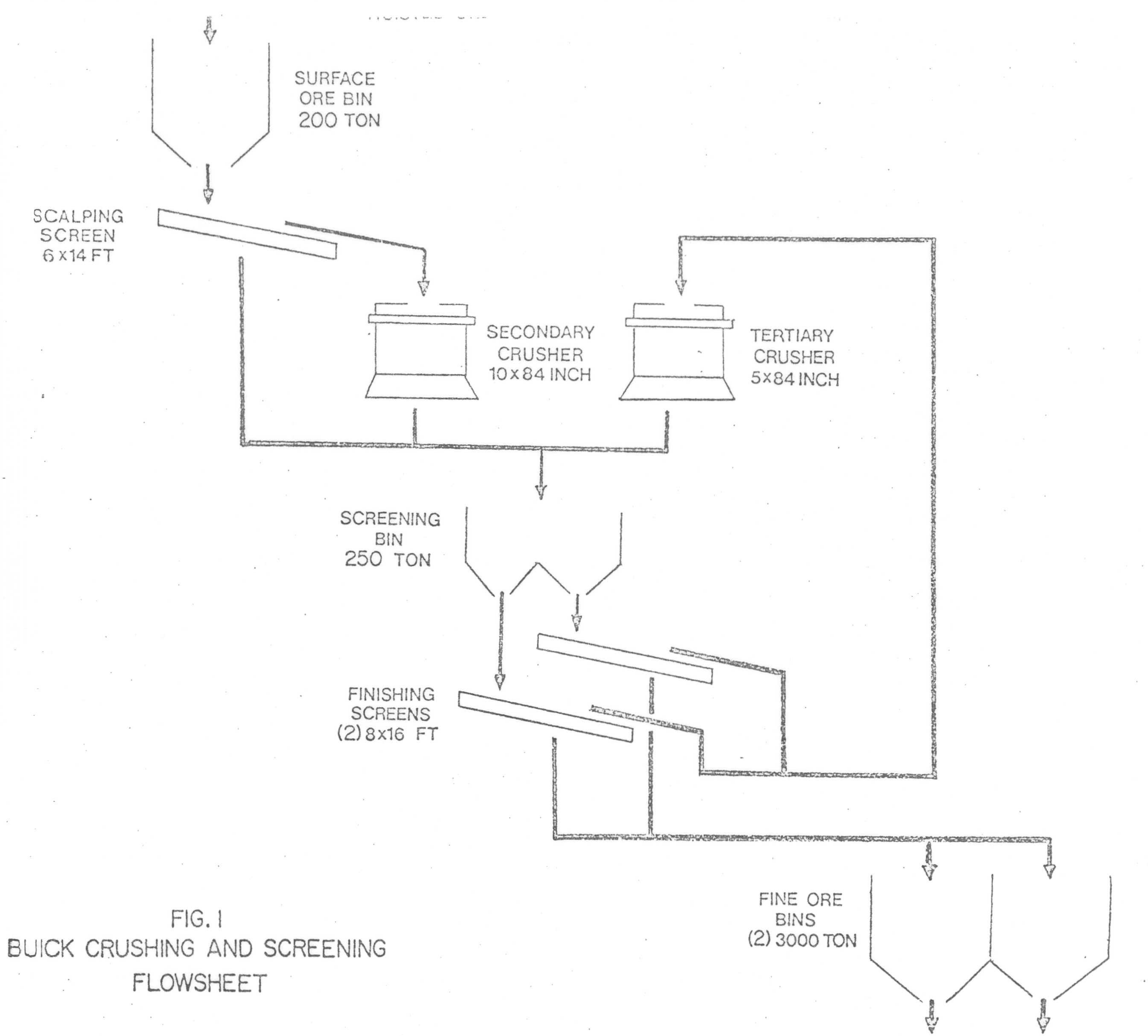

FIG. 1
BUICK CRUSHING AND SCREENING
FLOWSHEET

Following underground primary crushing to a nominal minus 6 inches, the ore is hoisted to the surface where it is discharged through Syntron vibrating feeders to conveyor belts. At the surface, the primary crushed ore can be conveyed directly to either the crushing plant or a surface stockpile.

In the crushing plant, the ore is conveyed to a Tyler 6 x 14 ft. double deck type scalping screen where a split of the plus and minus 1 1/2 inch material is made. The screen oversize is discharged to a 10 x 84 inch Allis Chalmers hydracone secondary crusher having a normal closed side setting of 1 1/8 inch. Scalping screen undersize and secondary crusher discharge are conveyed to two Tyler 8 x 16 ft. single deck screens where a split of the plus and minus 1 1/2 inch material is again made. Oversize from the 5/8 x 1 1/4 inch screens is crushed by a 5 x 84 inch Allis Chalmers hydracone tertiary crusher having a normal closed side setting of 1/2 inch. Discharge from the tertiary crusher joins the scalping screen undersize and secondary crusher discharge thereby constituting a closed crushing and screening circuit. Undersize from the two finishing screens is conveyed to a conventional side discharge tripper belt which discharges to two 3,000 ton live capacity fine ore bins.

Concentrator operations include grinding and classification, lead and zinc selective flotation, and lead and zinc thickening and dewatering. These operations are presented on the flowsheet in Figure 2.

Primary components of the grinding and classification section include a rod mill, a ball mill and cyclone classifiers operating in closed circuit, and equipment necessary to feed ore from two 3,000 ton fine ore bins.

Crushed ore is discharged to the rod mill feed conveyor system from the fine ore bins by four belt feeders, paired two to each bin. Each pair of feeders consists of one manually controlled and one automatically controlled feeder belt. The rod mill feed conveyor system is comprised of a collecting belt for transferring ore from the fine ore feeder belts and a feed conveyor which delivers the ore to the rod mill. The rod mill is a 12 x 16 ft. Hardinge overflow discharge mill which utilizes a 1,250 horsepower synchronous motor and operates at 60% of critical speed. Discharge from the rod mill is collected in a 8 x 10 x 13 ft. cyclone feed sump where it is delivered to classification by a 14 x 12 inch Denver SRL pump. Six Krebs 20 inch cyclones make up the classification section which operates with a 59% minus 200 mesh material in the cyclone overflow.

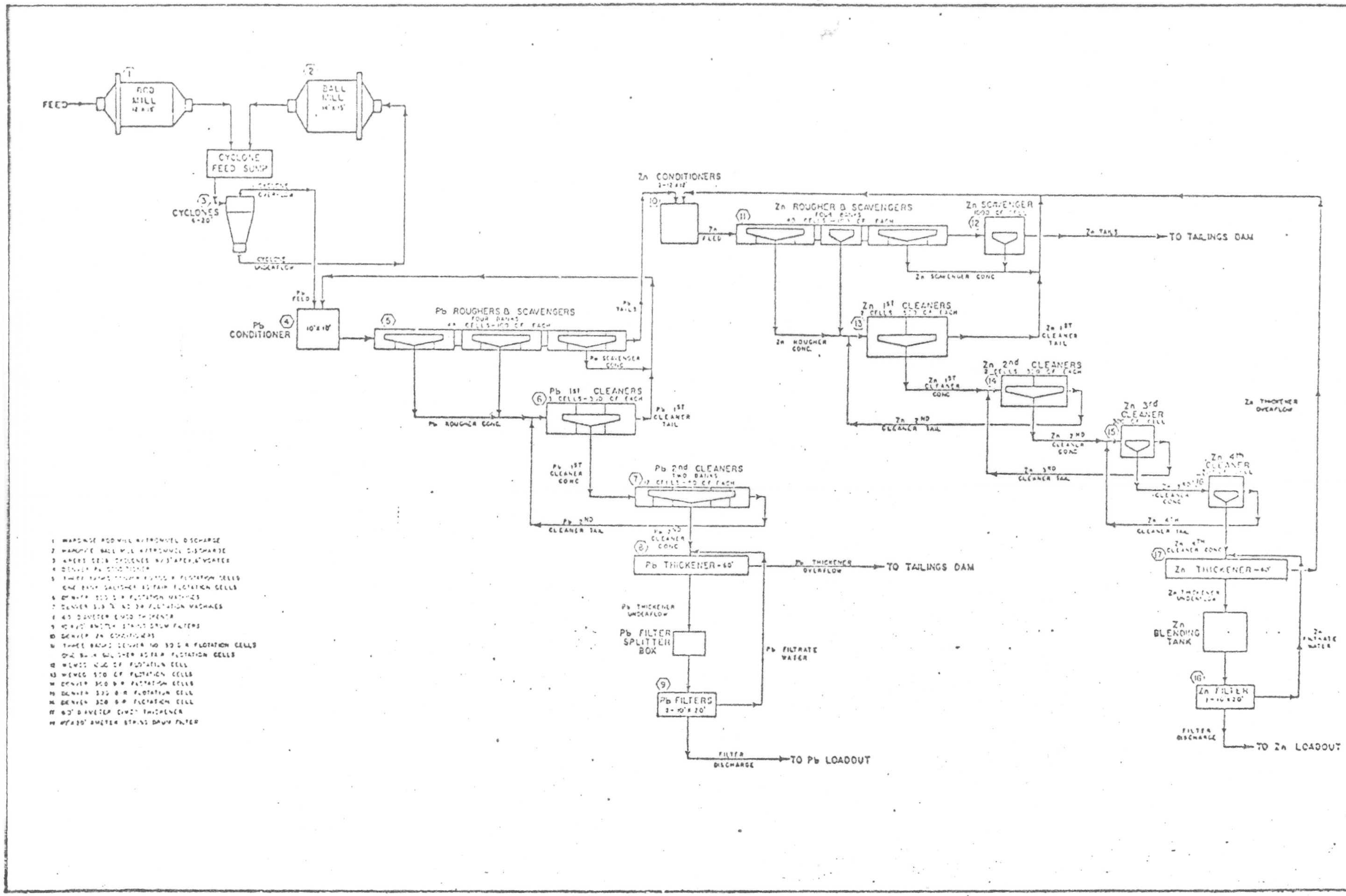

FIG. 2 BUICK CONCENTRATOR FLOWSHEET

Operating in closed circuit around the six cyclones is a 14 x 15 ft. Hardinge overflow discharge ball mill which also discharges to the cyclone feed sump and receives its feed from the cyclone underflow. The ball mill is equipped with a 1,750 horsepower motor and operates normally at 75% of critical speed. Overflow from the cyclone classifiers flows by gravity to lead flotation.

Rougher, scavenger, and cleaner flotation machines, combined with related pumps and blowers, are the basic components in the lead flotation process.

Cyclone overflow from the grinding circuit flows to a 10 x 10 ft. conditioner where the lead-zinc slurry is further diluted and conditioned with reagents prior to flotation. The conditioner tank overflow is distributed to four banks of Denver and Galigher flotation cells with each bank consisting of 12 cells. Total lead rougher and scavenger flotation capacity is 4,800 ft^3. Rougher froth from the first eight cells in each bank is pumped to the first stage of lead cleaning by a 8 x 6 inch Denver SRL pump. Scavenger froth from the last four flotation cells in each bank is returned to the lead flotation feed by a 4 inch Galigher pump. Tailings from the lead scavenger flotation are pumped by a 12 x 10 inch Denver SRL pump to the zinc circuit feed.

Three Denver 300 ft^3. flotation machines make up the first stage of lead cleaning which receives lead rougher flotation froth as feed. Concentrate from the lead first cleaners is pumped by a 8 x 6 inch Denver SRL pump to the second stage of lead cleaning. Tailings from the first stage of lead cleaning are returned to the lead flotation feed jointly with the lead scavenger concentrate.

Utilizing 600 ft^3. of capacity, the second and final stage of lead cleaning produces a final lead concentrate for thickening and a tailing which returns to the lead first cleaner feed. Two banks of Denver 50 ft^3. flotation machines, each bank consisting of six cells, are the constituents of the second stage lead cleaners. Final lead concentrate is delivered to the lead thickening and filtering section by a 8 x 6 inch Denver SRL pump.

Low pressure air for the lead rougher, scavenger, and cleaner flotation machines is supplied by two Spencer compressors.

The objective of the lead flotation circuit is to selectively float the galena mineral from sphalerite, pyrite, and gangue minerals to obtain a desired lead concentrate grade and lead recovery. The average lead concentrate grade is 75% with a normal lead recovery of 96%.

Prior to lead rougher and scavenger flotation, the lead-zinc slurry is diluted in the lead conditioner to 40% solids.

Xanthate, for galena collection, and zinc sulfate, for depression of sphalerite, are the primary reagents utilized in lead flotation. Addition point for both collector and depressant is the ball mill.

Xanthate adjustments are made as the lead metal in the mill feed varies. Normal addition ratio is .023 lb. per ton of lead metal feed yielding an overall lead recovery of 96%.

Zinc sulfate addition to the lead circuit is reasonably steady at .30 lb. per ton of ore feed. Excess zinc in the lead concentrate occasionally requires a slight increase in the zinc sulfate lb. per ton ratio, although an excess of the reagent can result in a reduced lead recovery.

MIBC (methyl isobutyl carbinol), the frother used, is added to the lead conditioner and is also distributed to the lead scavenger feed. Addition rates are constant and varied only if major tonnage changes occur.

Pyrite depression in lead flotation is obtained by the addition of sodium cyanide to the feed of the first stage of lead cleaning. Normal addition rate is .01 lb. per ton of ore feed and is dependent upon the iron assay in the mill feed.

Of considerable importance in lead flotation is air addition to the flotation cells. To maintain a desired lead recovery, varying lead grades in the mill feed requires adjustment of lead rougher and scavenger air flow to float more or less concentrate.

The air valve settings on the lead first cleaners are manipulated to maintain a reasonable lead grade in the lead first cleaner tailing. The desired grade is approximately equal to the lead grade in the mill feed. This insures controllable circulating loads and stable feed to the second stage of lead cleaning.

Air flow to the second stage of lead cleaning is varied to maintain an acceptable final lead concentrate grade. If an acceptable grade cannot be obtained with air adjustments, then a change in xanthate addition is justified.

In essence, to obtain the desired metallurgical performance in lead flotation, the simplified control strategy is to feedforward with reagents based on mill feed variables, and to feedback or trim with air flow adjustments based on circuit performance.

Following selective flotation, lead and zinc concentrates are each thickened in separate 60 ft. diameter Eimco thickeners. For each slurry, Galigher vacseal pumps deliver thickener underflows to the dewatering section. In the dewatering section, two 10 x 20 ft. Ametek string discharge drum filters are employed to filter the lead concentrate to a moisture of 8%. Both lead and zinc filters are connected to Nash vacuum pumps for dewatering.

Filtered lead and zinc concentrates are collected separately and conveyed to a concentrate storage area where they are shipped by rail or truck to various smelters or seaports.

HEALTH AND SAFETY PROGRAM

The health and safety program is conducted by the Safety Director who conducts periodic inspections of the beneficiation operations. A good housekeeping program includes an effort to remove residual dust from floors by wet sweeping and washing down as needed. A formal MSHA required health and safety training program is conducted by company personnel.

CONTROLS

The crushing and screening plants are primarily mechanical operations, although they require numerous sensors and instrumentation to function adequately. All crushing and screening operations can be regulated from a control room located in the crushing plant which includes a motor control panel, annunciator system, and indicators for major equipment operation. Both secondary and tertiary crushers are equipped with separate lube oil systems which incorporate hydroset mainshaft position indicators and controls. Bin levels in both crushing and screening plants are measured and indicated by Milltronics ultrasonic level devices.

Crushed ore, conveyed from the screening plant to the fine ore bins, is weighed by a Ramsey conveyor scale. Feed rate in conjunction with cumulative tonnage is displayed in the crusher control room.

Ore levels in the two fine ore bins are also measured and indicated by Milltronics ultrasonic level devices.

All control operations for the grinding and flotation circuits are performed from a centralized control room located between the grinding and flotation sections. Located in the central control room are all analog controls, recorders, and indicators for control of both grinding and flotation circuits. An annunciator system, mill bearing protection systems, and motor controls are also included in the centralized operations.

The grinding circuit is an automated operation in which the primary control objectives are to effectively control the particle size of the cyclone overflow product and to maintain an optimum circulating load, as measured by cyclone feed sump level, for maximum mill throughput. The grind control system stresses simplicity of field instrumentation and control strategy with the advantage of utilizing actual measurements for control rather than inferred values.

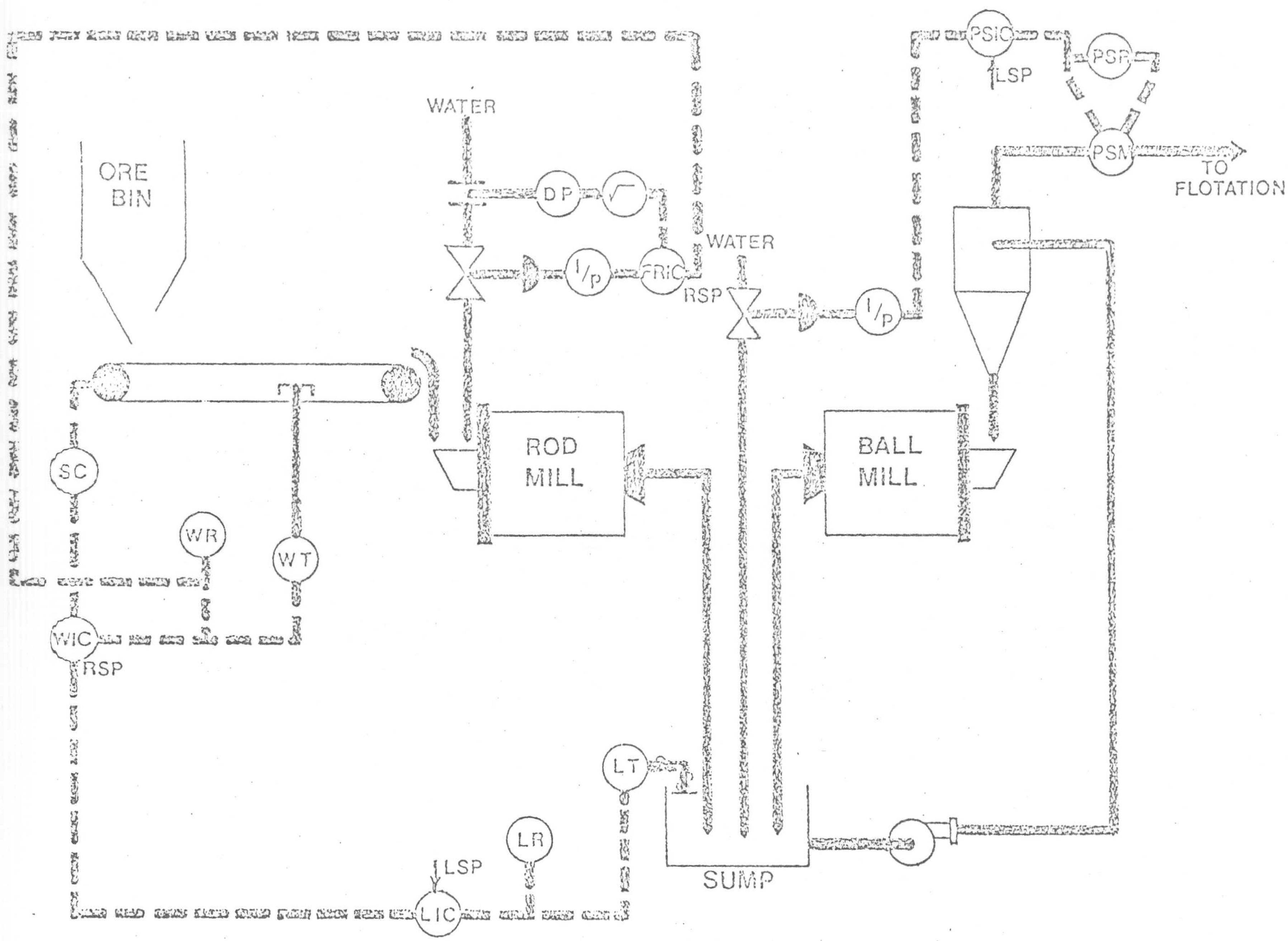

FIG. 3

BUICK CONCENTRATOR GRINDING CONTROL SCHEMATIC

Figure 3 shows the control system configuration for the grinding circuit. The rod mill feed rate, as indicated by a Ramsey conveyor scale, is compared to a cascaded setpoint which is obtained from the cyclone feed sump level control loop. Automatic manipulation of the fine ore feeder belts to maintain the cascaded feedrate setpoint closes the rod mill feedrate control loop. A constant slurry density is obtained within the rod mill by maintaining a constant preset ratio between rod mill feed rate and rod mill water addition. Headwater flowrate is measured with an orifice plate in conjunction with a differential pressure transmitter.

The cyclone feed sump level control loop, in which the sump level is compared to a manual setpoint value, adjusts the rod mill feedrate control loop setpoint. The sump level is measured with a Milltronics ultrasonic level system. The largest volume of flow into the sump is ball mill discharge; therefore, sump level measurement is a good indication of the circulating load. By regulating the rod mill feedrate, this control loop seeks to maintain a constant ball mill circulating load.

An Autometrics particle size analyzer measures and monitors the particle size and slurry density of the cyclone overflow product. Particle size distribution is expressed as the percentage of particles passing 200 mesh and is represented by a single measurement. The particle size control loop compares the measured particle size with a manual setpoint and adjusts water flow to the cyclone feed sump accordingly. By altering water addition to the cyclone feed sump, a change in cyclone split characteristic is obtained. The impact on the grinding circuit due to this control action is not only the control of cyclone overflow particle size, but is also a definite alteration in circulating load with the coarser-than-desired material returning to the ball mill. While the purpose of the size control loop is to control particle size, it also has a significant affect on ball mill loading, sump level, grinding circuit throughput, and constant flotation feed volume.

The lead and zinc flotation circuits are operated by controlling lead and zinc concentrate grades and recoveries through adjustment of reagents, by maintaining a desired flotation feed density, by controlling flotation pulp levels, and by flotation cell air adjustments.

The lead flotation feed density is controlled automatically at 40% solids by water addition to the lead conditioner. The density is measured with a Texas Nuclear density gauge.

The majority of the reagent feeding systems in the flotation circuits consist primarily of magnetic flowmeters and control valves which are fed from constant head reagent storage tanks. Fisher Porter magnetic flowmeters measure reagent flows in cc. per minute and indicate the flowrates in the control room. Masoneilan control valves are utilized as final control elements with the exception of ammonium copper chloride which requires a Dahl teflon trim control valve. Because xanthate and ammonium copper chloride reagents require close control and frequent adjustments, automatic feedback control of these reagents is essential.

Pulp levels in the lead flotation circuit are controlled manually with dart valves and weir overflow. The zinc flotation circuit pulp levels are also controlled manually with the exception of the Wemco scavenger and first cleaner cells which incorporate automatic control. In these flotation machines, pulp level is measured with a conventional bubble tube and controlled with a Foxboro pneumatic controller and actuated dart valve.

Air flow measurements are made for the low pressure air to the lead roughers and scavengers, the first stage of lead cleaning, and the second stage of lead cleaning. Fisher Porter flow tubes in conjunction with differential pressure transmitters measure air flows where applicable. Flow tubes were chosen over other conventional flow elements due to the low pressure loss and high recovery pressure characteristics of the tubes. All air adjustments are manual at individual flotation machines. Within certain limitations, adjustments of low pressure flotation air normally results in a very rapid and significant effect on the operation of flotation cells. The rapid response of the flotation circuit to variations in air flow makes this variable an excellent control parameter.

Of prime importance to the flotation circuit control is a continuous on-stream X-ray sampling system. An Outokumpu Oy Courier 300 on-stream analyzer, utilized to detect, compute, and display metal values in various pulp streams, is the single most important metallurgical tool for process control.

As the analyzer detects changes in assays in the various streams, reagent flows, air flows, and other flotation parameters can be adjusted. Through the application of the on-stream analyzer a higher level of metallurgical efficiency can be obtained by manual control over operating parameters.

The Courier X-ray system currently analyzes the following ten sample streams for lead, zinc, copper, iron, cobalt, and percent solids:

Lead flotation feed
Lead rougher concentrate
Lead circuit tailings
Lead first cleaner tailings
Lead final concentrate
Zinc circuit feed
Zinc rougher concentrate
Zinc circuit tailings
Zinc first cleaner tailings
Zinc final concentrate

A flowsheet of the X-ray sampling system is presented in Figure 4. A primary sample of approximately 50 gpm is obtained by utilizing launder samplers or pipe samplers. The primary sample streams are pumped by 2 inch vertical Sala pumps or flow by gravity to the X-ray secondary samplers where they are reduced to 5 gpm and further siphoned through the X-ray sample cell windows. The 5 gpm streams are again cut every 20 minutes by tertiary samplers for wet chemical assays. The remaining portion of the 50 gpm sample stream is then returned back to the original sample point.

The electronics associated with the X-ray system are very reliable and operate 99% of the time while sampling equipment functions 95% of the time. All assays are logged every 10 minutes as well as recorded on chart recorders every measurement round. The system also averages the various assays to obtain a shift and daily report.

Overall accuracy of the X-ray analyzer is quite acceptable with 5% or less relative error when compared with wet chemical analysis.

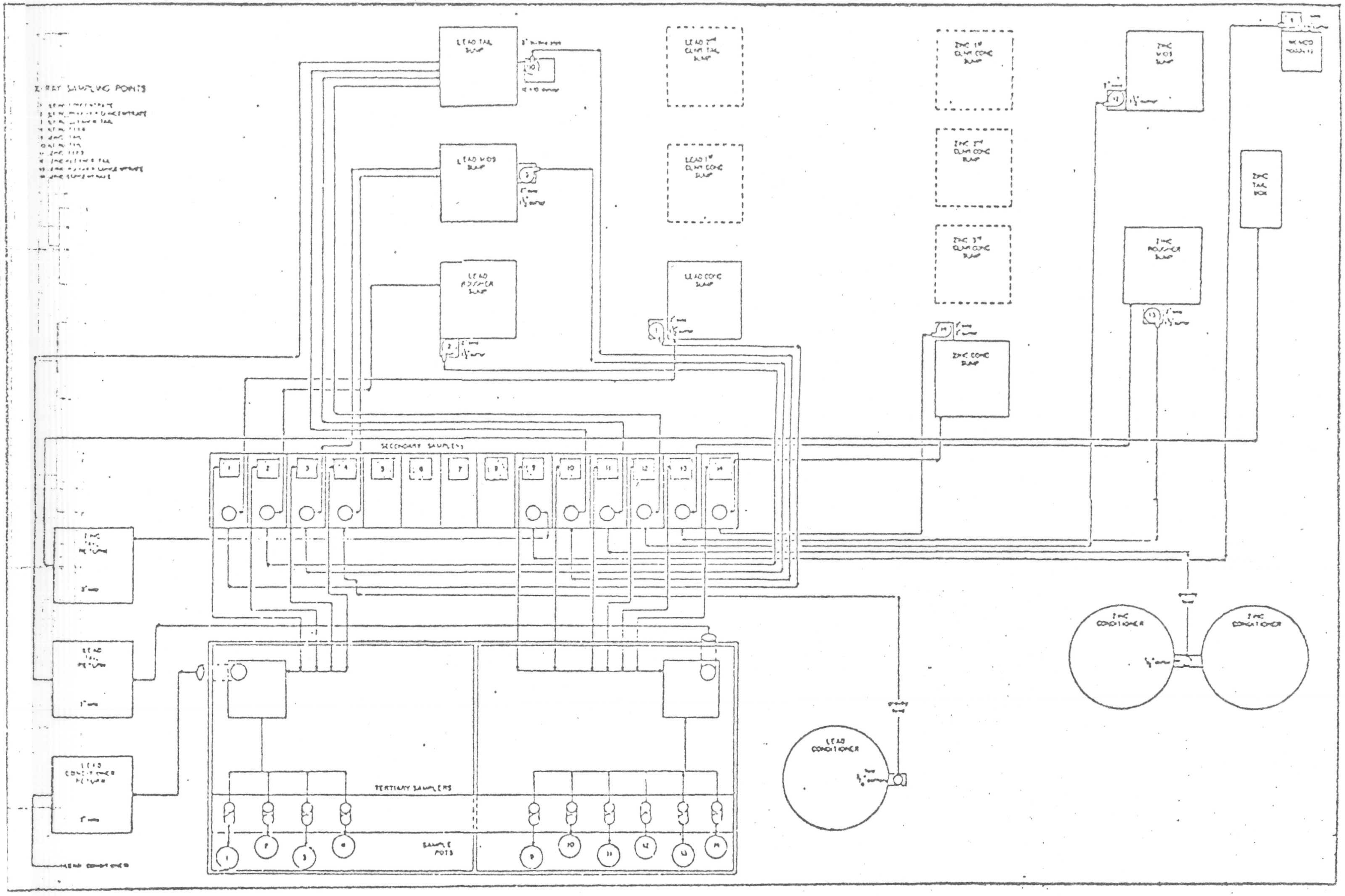

FIG. 4

BUICK CONCENTRATOR X-RAY SAMPLING SYSTEM

Control of concentrate thickening and dewatering involves minimal instrumentation and, as with the crushing and screening operations, is a straight-forward manual process. A local control panel in the filtering area is equipped with motor controls and an annunciator system. Ramsey conveyor scales measure, indicate, and totalize both lead and zinc filtering rates.

Other important state-of-the-art health and safety controls are:

1. In the reagent handling area, the use of a "water spike" to empty drums of cyanide and xanthate (Figure 5).

2. Use of an enclosed conveyor system.

3. Flotation cell launders widened from approximately 6" to 18" to minimize froth (bubbles) striking the launder sides on overflowing and thus reducing the quantity of mist generated.

CONCLUSIONS/RECOMMENDATIONS

The beneficiation operation at Amax Buick mill is recommended for an indepth survey. There are a number of locations within the operation with the potential for causing worker exposure to lead, dusts, and flotation reagents. Some of these potential exposure locations are equipped with controls designed to control the hazard. An indepth survey will provide an opportunity to evaluate these controls by determining the concentration of hazardous contaminants in the general work area air.