July 5, 1966 H. H. PICK ETAL 3,259,743

APPARATUS FOR SAMPLING AND ANALYZING A PLURALITY OF CONTINUOUSLY FLOWING STREAMS OF MATERIAL THROUGH FLEXIBLE CONDUITS

Filed Dec. 11, 1963 2 Sheets-Sheet 1

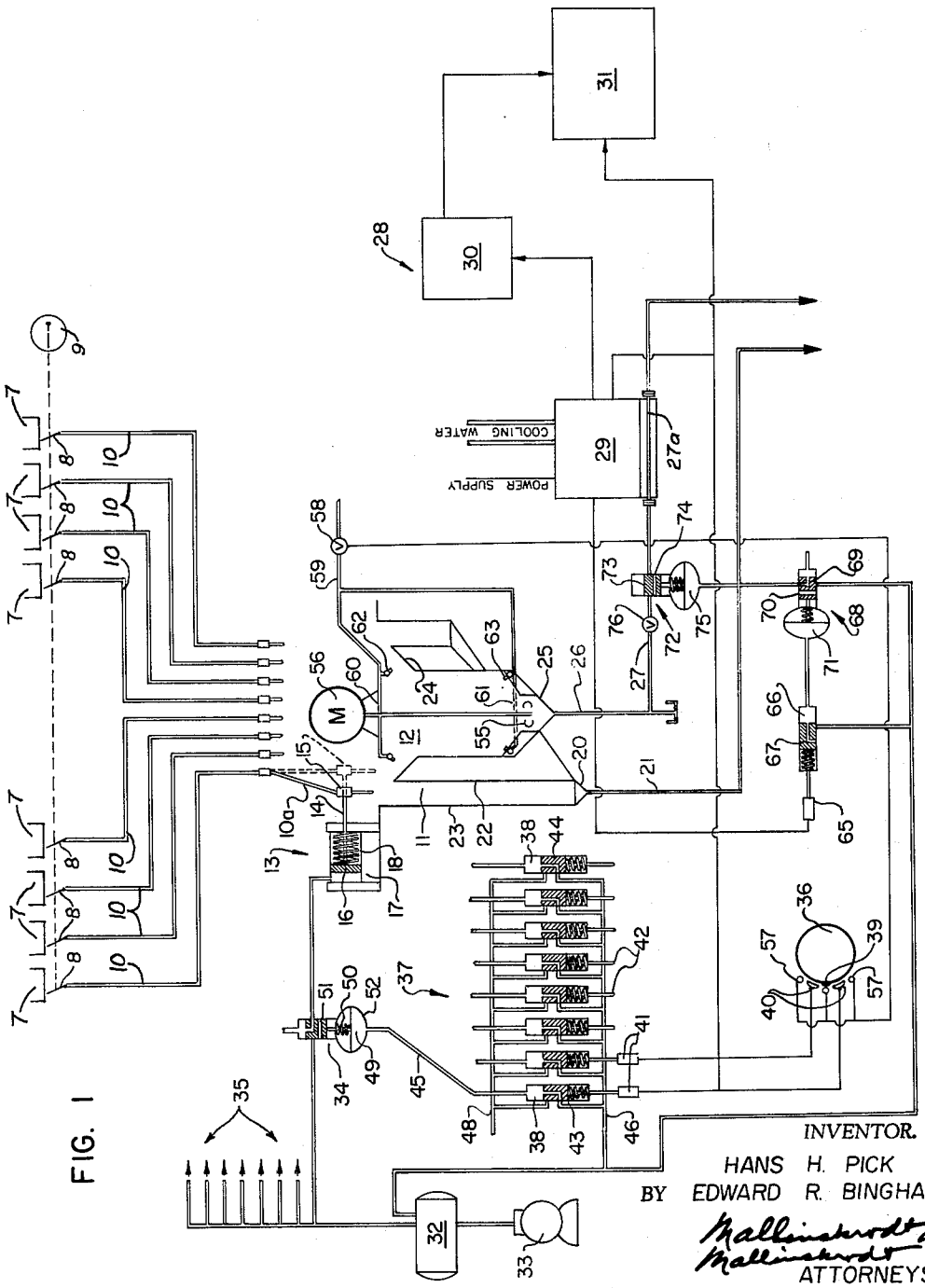

FIG. 1

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FIG. 3.

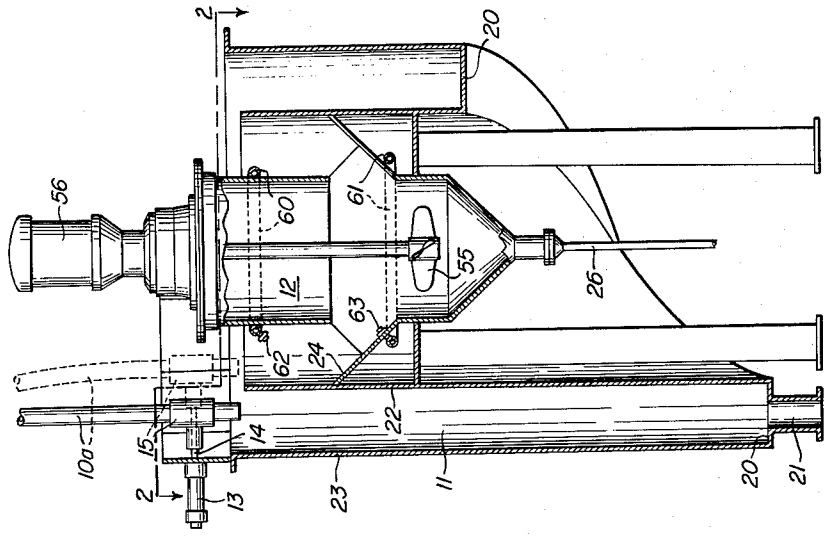
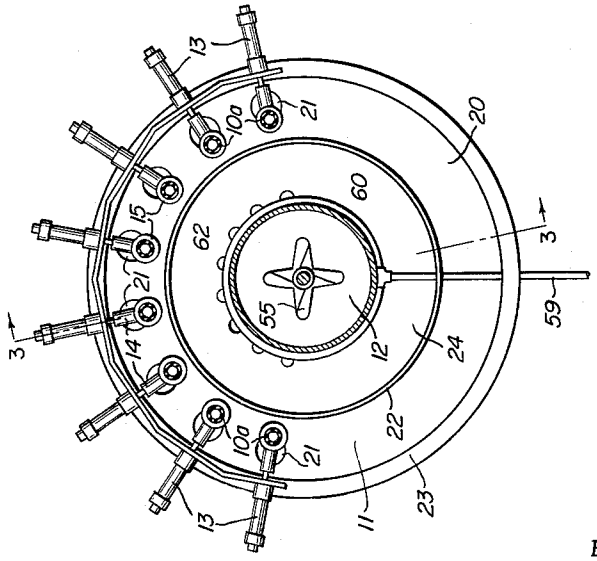


FIG. 2.



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APPARATUS FOR SAMPLING AND ANALYZING A PLURALITY OF CONTINUOUSLY FLOWING STREAMS OF MATERIAL THROUGH FLEXIBLE CONDUITS

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11 Claims. (Cl. 250—51.5)

The invention relates to the sampling and analyzing of flowing materials, such as metallurgical slurries, chemical solutions, other industrial liquids and semi-liquids, vapors, gases, and even discrete dry solids.

It is concerned with providing both method and apparatus for enabling several industrial operations to be individually controlled, either manually or automatically, by changes in analyses from time to time of respective streams of flowable materials passing through or discharged from such operations.

A known method and apparatus of this type developed for use in the overall control of several froth flotation circuits in the milling of metallurgical materials involves periodic cutting of samples from respective streams of material and reducing the size of each sample by successive cutting thereof to provide a final quantity of material adapted to fit into the sample presentation chamber of a standard X-ray spectrographic analyzer. Separate holding tanks are required for the several samples, along with a directionally valved system of conduits for sequentially introducing the respective samples into the presentation chamber, for sequentially evacuating such samples from the chamber, and for flushing the chamber between successive samples.

Principal objects in the making of the present invention were to do away with the necessity for separate holding tanks and for a complicated system of valved conduits, and to eliminate the need for reduction in sample size by successive cutting of each sample.

Principal features of the method in the accomplishment of these objects are the flowing of the originally cut samples through respective flow systems, either to recirculation or to waste as the case may be, depending upon whether the individual stream samples are of valuable material or of waste material; and the diverting of flow of sample material from selected individual flow systems, sequentially, into a common sample presentation system which may be equipped with material conditioning means, if required. Disposal of the material passing through the presentation system depends upon whether it is valuable, as for example metallurgical concentrates, or whether it is waste, as for example final metallurgical tailings.

Sample presentation is by continuous flow through a presentation tube. Flushing between individual samples can be employed if necessary or desirable.

Principal features of the apparatus developed for effectively carrying out the method with respect to metallurgical slurries and other semi-liquids are the provision of a conditioning vessel, as part of the sample presentation system, with an agitator and with a gravity outflow conduit leading into a through-flow, sample-presentation tube, in place of the usual sample-presentation chamber of an X-ray spectrographic sampler or other radiation applying and sensing device; the provision of a reject launder or other by-pass means in association with such conditioning vessel, as part of the individual sample flow systems; the provision of individual sampling devices for cutting samples from the respective streams of materials; the provision of individual conduits for the flow of samples from the respective sampling devices into

the by-pass means; and the provision of means for successively diverting flow from selected ones of such sample-flow conduits away from the by-pass means and into the conditioning vessel.

Where the by-pass means is a reject launder as previously indicated, the flow-diverting means preferably take the form of flexible discharge portions for the respective conduits, e.g. hoses, and respective devices for moving such discharge portions from positions over the reject launder to positions over the conditioning vessel, and vice versa. Such devices are conveniently power actuated under the control of a timer set to initiate sequential operation of the respective devices in accordance with a predetermined schedule.

With the present method and apparatus, the sampling and analyzing can be carried out on an overall continuous basis, if flushing between successive samples is not necessary, or on an overall periodic basis, if desired. In either case, the samples are presented for analysis substantially immediately after cutting, with no time delays in holding tanks nor other opportunity for setting.

There is shown in the accompanying drawings a specific embodiment of apparatus representing what is presently regarded as the best mode of carrying out the generic concepts of the invention in certain metallurgical practices. From the detailed description of this, other more specific objects and features of the invention will become apparent.

In the drawings:

FIG. 1 is a schematic representation of an overall arrangement of apparatus conforming to the invention and providing a metallurgical sampling and analyzing system for carrying out the method;

FIG. 2, a horizontal section taken on the line **2—2** of FIG. 3 and showing the sample conditioning vessel and by-pass launder in top plan; and

FIG. 3, a vertical section taken on the line **3—3** of FIG. 2.

Referring now to the drawings:

The apparatus illustrated is designed to sample the final tailings discharging in separate streams from respective outlets **7**, FIG. 1, of a plurality of froth flotation circuits, which make up a flotation mill operating on an ore pulp or slurry for the recovery of metal values contained therein.

The tailing streams, there being eight in this instance, are individually sampled on preferably a continuous basis by means of standard sampling equipment to provide a corresponding plurality of sample flows, each made up of successive samples from one of the streams. As illustrated, the required number of sample cutters **8** are operated in unison by a common drive arrangement **9** powered by an electric motor (not shown).

The samples cut from the several streams pass into respective conduits **10**, which are part of a series of sample flow systems corresponding in number to the number of streams sampled. Such flow systems have, in the present instance, structure in common in the form of a reject launder **11**, over which the conduits **10** are normally positioned for discharge thereinto. Reject launder **11** is associated with and provides a by-pass for a conditioning vessel **12**, which constitutes part of a sample presentation system.

In accordance with the generic concepts of the invention, means are provided for successively diverting flow from selected ones of the sample flow systems into the sample presentation system in order to provide quantitatively appropriate sample flow through a presentation tube which replaces the usual sample chamber of a standard X-ray, spectrographic analyzer or other radiation applying and sensing device.

In the present instance, such means include flexible discharge portions in the form of hose extensions **10***a* for the respective conduits and respective devices for moving such hoses from their normal positions over reject or bypass launder **11** to temporary discharge positions over conditioning vessel **12**.

A pneumatic motor **13** is provided to move each conduit **10**. The piston rod **14** of each motor carries a ring **15** at one end, through which the corresponding hose **10***a* is passed. Piston **16** is fixed to the other end of rod **14**, within cylinder housing **17** of the motor, and a spring **18**, disposed between an end wall of the housing and the piston, biases the piston and piston rod into the cylinder housing and normally holds the hose **10***a* in position above reject launder **11**.

Reject launder **11** is of annular formation, having a bottom **20** sloping to a discharge outlet **21** and an inner wall **22** extending upwardly from the bottom to a point below the top of an outer wall **23**.

Conditioning vessel **12** is positioned centrally of reject launder **11**, and has a lip **24** formed at its top so as to engage the top of inner wall **22** and direct any overflow of material from the conditioning vessel into reject launder **11**, which, in this illustrated form of apparatus, empties into a wase line **21**.

The bottom **25** of conditioning vessel **12** slopes to gravity discharge outlet **26**, connected through conduit **27** to a presentation tube **27***a* which passes through an X-ray spectrographic analyzer, shown generally at **28**, and then to a point of disposal, not shown.

As the material in presentation tube **27***a* passes through the head **29** of the X-ray spectrographic analyzer, it is irradiated, and by proper adjustment of control console **30**, in customary manner, the resulting wave lengths emitted by any particular material, or materials, are detected. The measured number of waves of a particular length are indicative of the amount of the material emitting the particular wave length and the amount of this measured material passing through the X-ray head is recorded on a conventional strip-chart recorder **31**. A model XEG General Electric X-ray spectrographic analyzer has been found satisfactory for the purpose, and the strip-chart recorder can be a Speedomax type G, manufactured by the Leeds and Northrup Co.

In operation, air is sequentially supplied from the air receiver taank **32** of air compressor **33** to pilot valves **34** in the pneumatic motor supply lines **35**. The sequence of actuation of the pneumatic motors **13** is controlled by an electrically motor driven timer **36** and a bank **37** of solenoid actuated control valves **38**. As cam **39** of the timer rotates counterclockwise, it sequentially closes switches **40** to energize solenoids **41** and retract plungers **42** to the position shown. This sequentially shifts the valve spools **43** from a normal spring biased position wherein the valve passages **44** interconnect the pilot valve supply and exhaust lines **45** with an exhaust conduit **48** to the illustrated position wherein the valve passages **44** interconnect supply and exhaust lines **45** and a supply line **46** from an air receiver tank **32** such that air is supplied to pilot valves **34** to open them, thereby allowing pressure to be applied to pneumatic motors **13**. For purposes of clarity, only one pneumatic motor **13** is illustrated in FIGS. 1 and 3 and only one pilot valve **34** is shown in FIG. 1, but it is to be understood that identical units are provided in each of the pressure lines **35**, and that one pressure line (shown fragmentarily) is provided corresponding to the flexible discharge portion **10***a* of each conduit **10**. The electrical control circuit is shown in FIG. 1, schematically, by solid lines interconnecting the various mechanical components.

During the period of time that each switch **40** is closed the following takes place: its corresponding solenoid **41** is energized; air is supplied the diaphragm chamber **49** of the connected valve **34**; the biasing effect of spring **50** is overcome; and the valve head is moved to a position wherein valve passage **51** interconnects pressure line **35** and the pneumatic motor at the rear of piston **16**. Pressure from line **48** acts on piston **16**, overcoming spring **18** to force the motor rod **14** out, and thereby moves hose **10***a*, carried by the rod **14**, from a discharge position over reject launder **11** to a second discharge position over conditioning vessel **12**.

After cam **39** passes each switch **40**, the switch is biased open, de-energizing its solenoid **41**. This allows the spring to bias the valve spool **43** to its exhaust position, relieving the air pressure acting on diaphragm **52** and permitting spring **50** to bias its valve head to exhaust position. Air is released from the pressure side of motor **34** and the piston and motor rod are biased by spring **18** to return the flexible hose **10***a* to its discharge position over reject launder **11**.

Timer **36** is programmed such that counter-clockwise rotation of cam **39** successively holds each switch **40** closed for a period of time, such as, for example, 60 seconds. This sequentially moves the flexible hoses into position over conditioning vessel **12**, and since the flexible hoses are larger than outlet **26**, conduit **27**, and presentation tube **27***a*, the material will continue to flow out of the sample receiver, even after switch **40** has again opened. Since agitator **55** within conditioning vessel **12** is constantly turning under the power of electric motor **56**, no settlement or segregation of material particles can occur, and the sample remains truly representative of the sampled material passing through the conduits **10**.

The timer continues to run after each switch **40** is opened and a time interval, i.e. 30 seconds, is provided during which material in the conditioning vessel is drained. At the end of each such drain period cam **39** contacts and closes one of the switches **57** to complete an energization circuit opening solenoid valve **58** in water supply line **59**. Water is then supplied to headers **60** and **61** and is sprayed thrrough nozzles **62** and **63** to flush out the head tank.

Another period of inactivity is provided by the timer to insure complete draining of all flush water and then another switch **40** is actuated to start the cycle with respect to another hose **10***a*. After all of the switches **40** have been closed and re-opened, in order, the timer will continue to run. Starting with the first switch **40**, they will again sequentially close each switch to initiate movement of the hoses between their two positions, while flushing the conditioning vessel between actuation of each hose.

Material passing out of conditioning vessel **12** through outlet **26** and conduit **27** is conducted through the X-ray spectographic analyzer **29** by sample presentation tube **27***a*, where it is assayed as previously described. Failure of the X-ray spectrographic analyzer, for example, due to rupturing of the Mylar window on the X-ray head, actuates solenoid **65** of valve **66** to move valve head **67** to an open position. Pressure fluid passing through valve **66**, which may be identical to previously described valves **38**, acts to open pilot valve **68**. Spool **69** of valve **68** is moved to a position wherein air is passed from air receiver tank **32** through passage **70** to an emergency valve **72**.

Emergency valve **72** has a valve head **73** normally spring positioned to align passage **74** with the passage through conduit **27**, and through which material flows to the X-ray spectographic analyzer. When pressure is applied to the diaphragm in pressure chamber **75** in response to failure of the X-ray spectrographic analyzer, passage **74** is moved such that valve head **23** precludes further flow through conduit **27**. This prevents damage to the X-ray spectographic analyzer that could occur if the material being tested were to continue to flow, and were to get into the sensitive machine parts. The cessation of operations also prevents continued recording of

data that, due to the malfunctioning X-ray spectrographic analyzer, may be misleading and erroneous.

In the event flow through conduit **27** and presentation tube **27***a* is stopped, either by the actuation of emergency control valve **72**, or by actuation of the manual control valve shown at **76**, the conditioning vessel will merely fill up, the material flowing over lip **24**, into reject launder **11** and out discharge outlet **21** to waste, or a point of use, as desired.

The above described arrangement has proved extremely useful in the sampling and analyzing of metallurgical slurries. Thus, in the illustrated arrangement, conventional sample cutters **8** are employed to "cut" samples of metallurgical material from "tailings streams" and to supply the samples to conduits **10**. The data obtained and indicated on recorder **31** allows proper manual or automatic adjustments to be made in the flotation circuit to insure maximum recovery of the material or materials being sought.

In those instances where all inlet conduits are being supplied from sources having a substantially similar composition, it may not be necessary to flush the head tank between samples. However, this depends to a great extent on the degree of accuracy required of each sample. If flushing is not required, switches **57**, headers **60** and **61**, and water supply line **59** can be omitted from the system.

When used on tailings streams in the metallurgical process above described, the reject launder **11** conveniently has but a single outlet and the plural inlets streams are all discharged therein for channeling to a disposal or waste pipe. Obviously, however, the same sampling and analyzing method and apparatus could be employed even if each inlet conduit normally discharged into a separate receiver before being transported to a point of use or back into a flotation circuit. This would be required in the event the material being handled were valuable, such as concentrates or preliminary tailings. In such an instance, a common overflow launder would still be required to receive overflow from conditioning vessel **12**, that may develop when material supplied the conditioning vessel is not passed through conduit **27** and presentation tube **27***a* at a rate sufficient to prevent overflow.

Whereas there is here specifically set forth certain preferred procedure and apparatus which are presently regarded as the best mode of carrying out the invention, it should be understood that various changes may be made and other procedures and apparatus adopted without departing from the inventive subject matter particularly pointed out and claimed herebelow.

We claim:

1. Apparatus for sampling and analyzing a plurality of streams of material, comprising

a corresponding plurality of flexible conduits through which said streams are passed, one to each conduit;

means for normally receiving the flow of material from said conduits;

a material analyzer having a sample presentation portion;

means for flowing material into said presentation portion of the analyzer;

and means for successively moving the individual flexible conduits between normal discharge positions with respect to said receiving means and sample discharge positions with respect to the means for flowing material to the analyzer.

2. The apparatus of claim **1**, wherein the means for flowing material to the analyzer is a conditioning vessel, and the means for normally receiving the flow of material from the conduits is a launder associated with but arranged to by-pass said vessel.

3. Apparatus according to claim **2**, wherein the material analyzer comprises an X-ray spectrographic analyzer and said presentation portion is a presentation tube.

4. Apparatus according to claim **3**, wherein a conduit interconnects the conditioning vessel and the presentation tube; valve means are provided in the conduit; and means are provided, responsive to failure of said X-ray spectrographic analyzer, to close said valve means, thereby preventing flow through said presentation tube.

5. Apparatus according to claim **2**, wherein the launder surrounds the conditioning vessel and is positioned to receive overflow therefrom.

6. Apparatus according to claim **5**, wherein the material analyzer comprises an X-ray spectrographic analyzer for continuously assaying material flow therethrough.

7. Apparatus according to claim **2**, wherein the flexible conduits have an internal diameter larger than that of the presentation tube.

8. Apparatus according to claim **7**, wherein agitator means are provided in the conditioning vessel.

9. Apparatus according to claim **2**, wherein said means for periodically and sequentially moving the flexible conduits includes a pneumatic motor connected to each flexible tube; means adapted to supply air to said motors; and means including a timer to sequentially supply and exhaust air from said motors in accordance with a preset time schedule.

10. Apparatus according to claim **2**, further including means for flushing the conditioning vessel between successive pneumatic motor operations.

11. Apparatus according to claim **10**, wherein the means for flushing the conditioning vessel includes a water supply line; a normally biased closed solenoid valve in said water supply line; a spray header in said conditioning vessel; and switch means actuated by the timer to periodically open said solenoid valve.

References Cited by the Examiner

UNITED STATES PATENTS

2,791,698	5/1957	Dyroff et al.	250—43.5
2,883,343	4/1959	Favre et al.	250—43.5
2,908,820	10/1959	Parsons	250—43.5

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