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UC-4 Chemistry - General
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KNOLLS ATOMIC POWER LABORATORY

SCHENECTADY, NEW YORK

BELGIAN SYMPOSIUM ON CHEMICAL PROCESSING I
SESSION: ENGINEERING OF RADIOCHEMICAL PLANTS
CONTACTORS AND AUXILIARIES

J. K. Davidson

June 27, 1957

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ABSTRACT

Several variations of the pulse column and mixer-settler contactors for liquid-liquid extraction in radiochemical facilities and pilot plants are described. Included are a 3/4-in. pulse column, a 1-in. vertical pulse column, the profile pulse column, and the concatenated pulse column. The mixer-settler systems include the pilot plant "Midi" mixer-settler, the laboratory "Mini" mixer-settler, a critically safe mixer-settler, and a continuous solvent wash unit. Details of necessary auxiliaries are discussed, and reference is made to designs and construction.

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T. J. Colven - duPont Company, Savannah River Plant
J. K. Davidson - Knolls Atomic Power Laboratory
E. J. Frederick - Oak Ridge National Laboratory
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A. C. Schafer, Jr. - Knolls Atomic Power Laboratory

BELGIAN SYMPOSIUM ON CHEMICAL PROCESSING I
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CONTACTORS AND AUXILIARIES

J. K. Davidson

I. INTRODUCTION

Both pulse columns and mixer-settler equipment have found wide application as the contactors for liquid-liquid extraction in development facilities and pilot plants. Variations of these contactors will be described with particular reference to small-scale facilities capable of handling feed streams of high activity. Although the facilities which are described are for pilot plants, the usefulness of this information for small plants is apparent.

II. SMALL PULSE COLUMNS AND THEIR AUXILIARIES

Pulse columns are described in detail in unclassified literature as well as in many AEC reports. A list of unclassified references is included at the end of this paper. The pulse column is based on a patent by Van Dijck and has undergone development at the Shell Development Company, Hanford, and Oak Ridge. It is a vertical column with stationary perforated plates. Agitation of the two phases is obtained by a cyclic pulse applied to the stream entering at the bottom of the column. The pulse forces the light phase through the small, perforated plates, after which the phase rises as tiny droplets to the next plate. The aqueous phase falls to the plate below on the pull of the push-pull pulse. The two phases move counter-currently by gravity at rates depending on the viscosity and difference in density of the two phases used in the column.

The details of a 5-in. pulse column are shown in Figure 1. The column is enlarged at the top and bottom to provide residence time for the separation of the mixed phases. The interface is controlled at the desired location by controlling the aqueous effluent rate with a pneumatic jackleg or a remotely controlled valve. Two interface dip tubes provide the sensing element for the remote controller. A variety of devices is used to provide the pulse; the choice is dependent upon the size of the column. Essentially, the devices are piston pumps without check valves. The connection between the pulse generator and the column is designed to create as little pressure drop as possible. A stainless steel bellows which is alternately compressed and extended is used with small units.

In order to obtain the required capacity and recovery of a particular system, the plate spacing, hole size, perforated area, pulse amplitude, and pulse frequency have to be determined in addition to the height and diameter of the system.

FIGURE 1

CONSTRUCTION FEATURES OF A FIVE-INCH SOLVENT
EXTRACTION COLUMN

THOREX "A" COLUMN AT ORNL

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A. Pulse Column Installation - Three-Quarter-Inch Diameter Columns

A typical small-scale development facility with pulse columns of 3/4-in. ID Pyrex pipe has been operated at Oak Ridge National Laboratory (ORNL). The installation consists of conventional 1A, 1B, and 1C columns. Figure 2 is a photograph of one column in this facility.

The pulse plates are of stainless steel spaced 1 in. apart and supported by a central stainless steel rod about 1/8 in. in diameter. Detailed information including dimensions of the columns and other equipment may be found in the Appendix. In addition to the columns, the facility includes tankage for the feed and product streams from the columns, a dissolver installation, and cold-feed make-up areas. The columns are fed by Pulsafeeder pumps manufactured by the Lapp Insulator Company. The column pulsers are also made by Lapp and are essentially the same as the pumps but with the checks removed. The columns are run with the aqueous phase continuous, and the interface at the top of the column is controlled by a differential pressure bubbler system as shown in Figure 3, with the exception that instead of the jackleg, a remotely operated control valve is used.

B. One-Inch Vertical Column System

Another example of a small-scale solvent extraction facility with pulse columns is the 1-in. vertical column system designed and constructed at ORNL. This facility is similar to the one described above and will not be described further. A complete set of drawings of the facility is available upon request from ORNL in care of E. J. Frederick. Identification of the drawings may be found in the Appendix.

C. The Profile Pulse Column

A small facility has been constructed at Hanford to test the feasibility of obtaining profile samples during operation of a pulse column. As described by W. Reas, the column itself consists of a compound column with a 1-in. ID extraction section and a 1-1/2-in. ID scrub section. Each section contains 50 sieve plates on 1-in. spacings. The sieve plates were assembled in short cartridges and mounted between the sample plates indicated in Figure 4.

The sample plates consist of a plane flange of stainless steel. A groove was milled into one side of the stainless steel flange to serve as a trap for the aqueous phase. A depression was turned into the center of the flange on the other side, and a Fluorethene liner was inserted to serve as a trap for organic phase. The center hole in the sample plate is large enough so that it offers no opposition to flow. Both sample traps communicate by way of drilled radial passages to the tube fittings to which are affixed 1/8-in. stainless steel sampling lines.

The pulse generator for this column consists of a Teflon bellows driven by an offset cam powered by a Graham variable speed drive unit.

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FIGURE 2. Three-Quarter-Inch Pulse Column Installation

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FIGURE 3 INTERFACE CONTROL SYSTEM

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FIGURE 4. Dual Purpose Profile Pulse Column

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The profile pulse column was operated with no shielding on feeds containing tracer levels of Zr-95 as a prototype of an installation being designed. The design incorporates separate extraction, scrub, and stripping columns; sufficient shielding for feed activities as high as 5% of plant level will be included.

D. Concatenated Pulse Columns

The vertical space requirements of pulse columns may be shortened by dividing the column into short concatenated sections. An article by Jealous and Lieberman⁵ is an excellent summary of the development work done on concatenated columns at ORNL. A list of drawings which are applicable to this device appears in the Appendix.

E. Pulse Column Auxiliaries

Detailed information on the subject of pulsers is given in the Appendix. All pulse generators described have been operated in a directly maintained radiochemical processing plant. The generators are separated from the pulse column and are located in a limited access area of the plant where maintenance and repair may be performed with a minimum of decontamination. The pulse line connecting the pulse generator to the column is purged with the decontaminated organic extractant or with water to prevent radioactivity from coming in contact with the generator.

III. MIXER-SETTLERS AND THEIR AUXILIARIES

The characteristics of mixer-settler equipment have been described in detail in the unclassified literature; a list of references is included at the end of the report. Three types of mixer settlers have received serious attention; the Standard Oil Development Co. contactor developed by Standard Oil and the Argonne National Laboratory, the Fenske Stacked extractor, and the pump-mix type* developed at the Knolls Atomic Power Laboratory. The pump-mix device has found the widest application. The operation of this unit was described in an earlier paper,¹⁰ and it will suffice to say here that the unit is a horizontal arrangement of stages with co-current flow in each stage and over-all countercurrent flow in the system. The interface in each stage is controlled by the action of the impeller, which also provides the mixing required for mass transfer. In development work, two types of this contactor, each with a distinct function, have evolved. Installations in which each of these units are used will be described below.

*U.S. Patent 2,646,346, "Multistage Mixer-Settler Apparatus," B. V. Coplan, et al. (Issued by U.S. Government July 21, 1953: filed by the U.S. Atomic Energy Commission.)

A. Pilot Plant Installation - "Midi" Mixer-Settler Units

The "Midi" pump-mix mixer-settler has a capacity of approximately 1 liter/min of both phases and provides information on capacity, settling characteristics, mixing speed, uranium stage requirements, and other operating characteristics of the flow sheet. All of this information can be obtained by using inactive feeds; the resulting data are the basis for scale-up (if it is required) and, in general, the larger units can be designed with no further testing information beyond that provided by the "Midi" or pilot plant equipment. The auxiliaries for this cold pilot plant consist of feed tankage mounted on scales, feed pumps of the positive displacement type, a multistage sampling unit, and the usual make-up tankage. Figure 5 is a drawing of the latest version of this mixer-settler facility. The pilot plant model consists of 16 stainless steel stages arranged side by side (see Figure 6). Each stage is a rectangular box 3-in. wide by 5-in. high by 11-in. long divided into two sections - a mixing section and a settling section. Each mixing section contains a stirrer on a shaft, which enters the mixing section through the top of the stage. The shaft supporting the stirrers is mounted on ball bearings and is driven by a belt and pulley. Speed control is obtained by means of a thymotrol rectifier, which controls a 1/4-hp dc shunt-wound motor. The stirrers act as centrifugal pumps and have an inlet tube extending below the impeller. The stirrer is shown in Figure 7. Both the light and heavy phase weirs are fixed, but flow over the aqueous weir is controlled by means of a jackleg and nitrogen pressure on the weir. Pressure on the weir is maintained constant by means of a mercury manostat. Drawings are available for the pilot plant unit and reference to them is given in the Appendix.

B. The "Mini" or Miniature Mixer-Settler

This is the smallest of the mixer-settlers. It provides the means of determining flow sheet behavior on small quantities of highly active feed; for instance, one liter of Purex feed is sufficient for a series of four or five runs performed to investigate the effect of several flow sheet parameters on decontamination losses, uranium-plutonium partition, and solvent damage. In addition, runs with inactive feed can provide information with respect to stage requirements, flow sheet stability, and the effect of impurities or additives.

Installation of the "Mini" mixer-settler provides a companion and complementary piece of equipment for the pilot plant unit necessary for the scale-up which was mentioned above. This unit was developed at the Knolls Atomic Power Laboratory (KAPL); similar units are now in operation at Argonne National Laboratory, Hanford, ORNL, and the Savannah River Laboratory. In the more recent installations, three such units are operated in cascade. Their small size enables them to be installed in a standard laboratory hood with lead or lead glass bricks as shielding. A large amount of data may be obtained on small volumes of process solution with a minimum investment. As with the larger mixer-settlers, stage samples can be obtained for equilibrium data. The unit itself is made from Fluorethene and stainless steel. The

FIGURE 5. PUMP MIX-MIXER SETTLER
PILOT PLANT SIZE

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FIGURE 6. Sixteen-Stage "Midi" Mixer-Settler

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FIGURE 7. Pump-Mix Impeller

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total volume per stage is about 10 cc. Each settling section is approximately $3/8$ in. square by about 2 in. high. A 16-stage unit is shown in Figure 8. The stirrers are driven by a gear-train system and a single small electrical motor mounted on each unit. Drawings of these units are available and their identification is included in the Appendix.

A facility for the study of high level plutonium solvent extraction has been operated at KAPL. It consists of a cascade of miniature mixer-settlers of the type just described, mounted in laboratory hoods and modified for plutonium handling. Figure 9 is a photograph of the "Mini" cascade installation. The mixer-settler equipment was mounted in a glove box inside of the hood. A modified mixer-settler system has been integrated with an existing high level feed preparation cell. The "Mini" units and their hoods are backed against a high level cell so that feed and waste stream lines can be connected between the systems. The hot feed is transferred to the mixer-settlers by an indirect scheme in which cold mineral oil is pumped through the feed system into the hot feed vessel. In this way the feed solution is displaced at a controlled rate to the contactors. A suction line operating at the A, or decontamination, bank weir returns the aqueous waste stream to the shield for storage.

An installation similar to the one described above has been constructed and operated at ORNL. A third such installation is in existence at Hanford and has been described previously.^{17,18}

C. Critically Safe Mixer-Settler

A critically safe mixer-settler in slab geometry has been described by T. J. Colven, Jr., of the duPont Company. In the test unit (Figure 10), the stages were 8 in. wide by 5 ft long and had an inside stage height of 3 in. The unit is of the pump-mix type and has operated successfully at total flows of 4 gpm on both Purex and Redox types of solution. Uranium transfer efficiencies of over 80% were obtained. This 6-stage unit has operated for over 1000 hr without mechanical difficulty.

D. Continuous Solvent Wash Unit

T. J. Colven reports that continuous solvent washers of the type shown in Figure 11 have been used to remove fission-product activity from tributyl phosphate - kerosene solvents. Gross gamma decontamination factors of 5 to 10 have been obtained at flow ratios as high as 100 volumes of solvent per 1 volume of wash (4% sodium carbonate). Processing rates as high as 20 gpm have been attained.

The design criteria for continuous washers are as follows:

Mix ratio - greater than 5 volumes of wash per 1 volume of solvent.

Recycle ratio - greater than 5 volumes of solvent recycle per 1 volume of feed.

Discharge into aqueous phase.

Power per 1000 gallons pumped by the paddle - 4 hp.

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FIGURE 8. Sixteen-Stage "Mini" Mixer-Settler

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FIGURE 9. "Mini" Cascade Installation for High Level Plutonium

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FIGURE 10. Slab Type Mixer-Settler Unit

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FIGURE 11. CONTINUOUS SOLVENT RECOVERY UNIT

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A critically safe solvent washer is shown in Figure 12. Only the fluid hydraulics of this unit have been tested, but effective processing capacities up to 0.5 gpm are expected.

E. Steam Jet Siphons for Pumping Radioactive Feeds

The operation of steam jet siphons has been satisfactory in transferring aqueous and organic liquids containing radioactive material. The operating characteristics of typical steam jets are given in Table 1. The jets are easy to build, require no maintenance, and are reliable pumping devices. Scale drawings of two jets are given in Figures 13 and 14.

For optimum operation a high (~85%) quality of steam must be supplied to the jet and no leaks must occur on the suction side of the jet. Normal jet dilution of process streams is about 3% by weight, and the most adverse temperature rise measured was 60°F. Steam consumption is proportional to the flow rate: about 1000 lb/hr for the constant rate C jet. Solvent jets require feed temperatures below 85°F for satisfactory operation.

FIGURE 12

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CRITICALLY SAFE SOLVENT WASHER

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TABLE 1. Operating Characteristics of Steam Jets

<u>Jet Type</u>	<u>Head, ft</u>	<u>Lift, ft</u>	<u>Solution</u>	<u>Specific Gravity</u>	<u>Flow Rate, gpm</u>	<u>Steam Pressure Range, psig</u>
Variable Rate Jets						
MF-1	20.5	6.0 to 12.5	Aqueous	1.49	2.0 to 4.0	105 to 140
MF-2	17.0	8.0 to 12.0	Aqueous	1.50	1.7 to 3.7	85 to 140
OF-1	26.0	4 to 7	Kerosene**	0.84	7.5 to 11.5*	80 to 120
OF-2	23.0	4 to 6.5	Kerosene**	0.84	2.2 to 3.2*	85 to 130
OF-3	23.0	4 to 11	Kerosene**	0.84	3.5 to 5.6*	90 to 110
OF-4	26.0	4 to 7.5	Kerosene**	0.84	13 to 27*	87 to 120
OF-5	23.0	4 to 8	Kerosene**	0.84	22 to 45*	75 to 130
Mod Z	7.0	6.25 to 12.5	Aqueous	1.52	3 to 4.75	62 to 95
	21.5	6.0 to 12.5	Aqueous	1.52	3 to 4.8	97 to 130
Z-1 XW	20.0	5 to 9.25	Aqueous	1.14	1 to 3.5	75 to 140
	19.0	6.5 to 10	Aqueous	1.51	1 to 2.25	100 to 140
Z-5	19.0	6.2 to 13	Aqueous	1.04	4 to 10.5	66 to 95
	19.0	6.0 to 12	Aqueous	1.11	4 to 10	68 to 100
	20.0	13.0	Aqueous	1.48	4 to 6.8	92 to 110
Z-6	19.0	6.3 to 12.8	Aqueous	1.06	8 to 20	70 to 110
	19.0	6 to 12	Aqueous	1.10	8 to 16	75 to 100
	20.0	13.0	Aqueous	1.42	5.8 to 7.7	100 to 113
Constant Rate Jets						
E	24.0	4 to 12	Aqueous	1.0	20	90 to 140
	24.5	4 to 12	Kerosene**	0.84	15	80 to 140
S ₁	24.5	4 to 12	Aqueous	1.0	33	100 to 140
	24.5	4 to 12	Kerosene**	0.84	25	85 to 140
S ₂	75.0	10	Aqueous	1.0	25	100 to 140
C (Low lift)	24.5	4 to 12	Aqueous	1.0	100	85 to 140
C (Low lift)	24.5	5 to 12	Kerosene**	0.84	77 to 88	80 to 140
C (High lift)	21.5	17.5	Kerosene**	0.84	50	80
CB	62.0	4 to 12	Aqueous	1.0	90 to 113	115 to 140
D	45.0	12 to 14	Aqueous	1.23	50 to 95 at 115°F	50 to 90
	to 90.0					

*Maximum temperature of feed to jet = 80°F.

**Viscosity - 15 to 20 mp at 25°C

Flash point - 170°F.

FIGURE 13
VARIABLE RATE JET

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FIGURE 14
CONSTANT RATE JET

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APPENDIX

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DETAILED INFORMATIONTHREE-QUARTER-INCH DIAMETER PULSE COLUMN LAYOUT (VERTICAL COLUMNS), EQUIPMENT, AND EQUIPMENT SPECIFICATIONSPulse Column Details

A-Column: 0.750-in. ID "Trubore" Pyrex glass pipe. Type 347 stainless steel pulse plates (0.060-in. holes, 23% free area, 0.748 in. OD) spaced 1 in. apart on 3/32-in. diam Type 347 stainless steel welding rod with 1/8-in. OD, 0.032-in. wall Type 347 stainless steel tubing spacers. Type 347 stainless steel feed point at 10-ft cell elevation. Column has 2 ft ID x 12-in. long bottom bell, 8 ft of extraction section, 10 ft of scrub section, and a 2-in. x 18-in. top bell with 3/4-in. ID organic overflow and interface drain side arms. Top bell also has vent and interface controller instrument lines.

B-Column: 0.750-in. ID "Trubore" Pyrex glass pipe. Type 316 stainless steel pulse plates (0.040-in. holes, 23% free area, 0.748 in. OD) spaced 1 in. apart on 3/32-in. diam Type 347 stainless steel welding rod with 1/8-in. OD, 0.032-in. wall Type 347 stainless steel tubing spacers. Type 347 stainless steel feed point at 8-ft cell elevation. Column has 2-in. ID x 12-in. long bottom bell, 6 ft of back extraction section, 8 ft of partition section, and a 2-in. ID x 18-in. long top bell with 3/4-in. ID organic overflow and interface organic side arms. Top bell also has vent and interface controller instrument lines.

C-Column: 0.750-in. ID "Trubore" Pyrex glass pipe. Type 316 stainless steel pulse plates (0.040-in. holes, 23% free area, 0.748 in. OD) spaced 1 in. apart on 3/32-in. diam Type 347 stainless steel welding rod with 1/8-in. OD, 0.032-in. wall Type 347 stainless steel tubing spacers. Column has 2-in. ID x 12-in. long bottom bell, 8 ft of strip section, and a 1-1/2-in. ID by 14-in. long top bell with 3/4-in. ID organic overflow side arm.

Tanks: Dissolver, feed make-up

A-Column - Feed, organic solvent, waste, and scrub

B-Column - Scrub, strip, and product

C-Column - Strip, waste, and product.

Tanks are fabricated of Type 347 or 304-L stainless steel. Tank capacities are coordinated with flow sheet conditions.

Pumps: Vendor - Lapp Insulator Company, Inc.
 Process Equipment Division
 LeRoy, New York

Contact - Mr. L. F. Wilson

Requirements: Three pulsers - Lapp Pulsafeeder pump, Type CPS-1 pulser.
 Remote head variable speed.

A-Column Feed	- Lapp Pulsafeeder pump, Type CPS-1 pulser, remote head.
A-Column Scrub	- Lapp Microflo Pulsafeeder, Type LS-1.
A-Column Solvent	- Lapp Pulsafeeder pump, Type CPS-1 pulser.
B-Column Scrub	- Lapp Microflo Pulsafeeder, Type LS-1.
B-Column Strip	- Lapp Microflo Pulsafeeder, Type LS-1.
C-Column Strip	- Lapp Pulsafeeder pump, Type CPS-1 pulser.

Pump Specifications

Pulser Pumps

Lapp Pulsafeeder pump, Type CPS-1 pulsers, assembled complete, and in accordance with the following specifications:

Product - unknown
 Specific gravity - 1.20
 Pumping temperature - room
 Operating pressure - 30 ft positive
 Suction pressure - 30 ft positive
 Maximum pump capacity - 11.5 gph at 58 strokes/min.
 Design pressure - 250 psig
 Stroke length - 1.0 in.
 Piston size - 1.0 in.
 Strokes per minute - 30 to 100 required; 33 to 100 actual
 Valve type - none
 In and out connections - 1/2 in.
 Pipe size welding nipple - 3/4" stainless steel, compression fitted to head
 Valve housing - none
 Diaphragm - 316 stainless steel with gold gaskets
 Reagent head - 316 stainless steel, remote head.

Other details: Single remote reagent head has valves fitted with gold-gasketed 3/4" stainless steel welded nipple. Diaphragm gaskets of gold. Backing plate of 316 stainless steel. All bolts are 316 stainless steel with compression fitted outlets.

Motor: 1/3-hp, 110-volt, 60-cycle, single-phase, ac, explosion proof, gear head speed ranger, assembled to Pulsafeeder pump.

A-Column Feed Pump

Lapp Pulsafeeder pump, Type CPS-1, proportioning, assembled complete, and in accordance with the following specifications:

Product - unknown
 Specific gravity - 1.25
 Pumping temperature - room
 Maximum flow - 2.9 gph
 Operating pressure - 30 ft positive
 Maximum pump capacity - 2 gph
 Design pressure - 250 psig
 Stroke length - 1 in.
 Piston size - 0.5 in.
 Strokes per minute - 58
 Valve type - ball
 Number suction valves - 1
 Number discharge valves - 1
 Valve material - 316 stainless steel
 Seat material - 316 stainless steel
 Discharge spring-loaded - no
 Suction spring-loaded - no
 In and out connections - 1/4-in. welding nipple in 347 stainless steel
 Valve housing - 347 stainless steel
 Diaphragm - 316 stainless steel with gold gaskets
 Reagent head - 316 stainless steel, flow-through type.

Other details: Remote reagent head assembly with 316 stainless steel backing plate in accordance with plan A of data sheet No. 443. All gaskets on reagent head assembly to be gold.

Motor: 1/3-hp, 110-volt, 60-cycle, single-phase, ac, 1725-rpm, Class I, Group D, explosion proof, assembled to the Pulsafeeder pump.

A-Column Organic and C-Column Strip Pumps

Specifications for these pumps are identical to the specification for the A-Column feed pump with this exception: the reagent head shall be of 316 stainless steel and a flow-through type instead of a remote head.

A-Column Scrub, B-Column Scrub, B-Column Strip, and C-Column Strip Pumps

Lapp Microflo Pulsafeeder pump, Type LS-1, in accordance with the specifications below and including a 1/20-hp, 110-volt, 60-cycle, single-phase, ac, 1725-rpm, Class I, Group D, explosion-proof motor.

Product - unknown
 Specific gravity - 1.25
 Pumping Temperature - room
 Maximum flow - 2150 cc/hr
 Operating pressure - 30 ft
 Maximum pump capacity - 2150 cc/hr
 Design pressure - 1000 psig
 Stroke length - 0.5 in.
 Piston size - 0.375 in.
 Strokes per minute - 44
 Valve type - ball
 Number suction valves - 2
 Number discharge valves - 2

Valve material - 316 stainless steel
 Seat material - 316 stainless steel
 Discharge spring-loaded - no
 In and out connections - 1/4 in.
 welding nipple in 347 stainless
 steel
 Valve housing - 347 stainless steel
 Diaphragm - 316 stainless steel
 with gold gaskets
 Reagent head - 316 stainless steel

Other details: gold gaskets on all
 valve seating surfaces and
 diaphragm.

General

Certified dimensional drawings, performance curves, installation and maintenance instructions are required for each pump. Parts lists for each pump type including a description of each part with "W" number reference is required.

CONCATENATED COLUMNS

A list of ORNL drawings which give details for the installation of concatenated columns in the Thorex pilot plant is presented below. The drawings of the D column are more recent and represent the latest stage of concatenated column design.

TABLE A-1. List of ORNL Drawings for Concatenated Columns

	<u>Thorex D Column</u>	<u>Thorex B Column</u>
Column Design	D-23550, C-23551	D-14561
Layout	D-23533	D-11707
Piping	E-23567	D-11201
Plate	C-14523	C-14523
Check valve	C-23538	C-11739, C-11740
Flow sheet	E-23561	E-9172

ONE-INCH PULSE COLUMNS

A list of ORNL drawings which provide details of construction for a 1-in. pulse column facility can be found on the following pages.

TABLE A-2. List of ORNL Drawings for the One-Inch Pulse Column Facility

<u>Area</u>	<u>Title</u>	<u>Dwg. No.</u>	<u>Latest Revision</u>
Cell and Roof	Adjustment and Extraction	E-23496	1
Cell and Roof	Product Concentration System	E-23497	1
Cell and Roof	Miscellaneous Collection System	E-28683	
Make-up and	Make-up and Metering System	E-23498	1
Roof			
Sample	Sampling System	E-28684	

Equipment Design

<u>Area</u>	<u>Title</u>	<u>Symbol</u>	<u>Dwg. No.</u>	<u>Latest Revision</u>
Cell	Standard Receivers	U-13, -14, -15, -21, -22, -24, -32, -33 and -34	E-28677	
Cell	Receiver Caps and Special Details	U-13, -14, -15, -21, -22, -24, -32, -33 and -34	E-28676	
Cell	Evaporator Pot	U-30	E-28678	
Cell	Phase Separator	U-23	E-28685	
Cell	Feed Adjustment Receiver	U-12	D-28686	
Cell	Column Details - Pulse Plate Sections	U-10, U-20	D-28679	
Cell	Column Details - Upper Sections	U-10, U-20	D-28680	
Cell	Column Details - Lower End Sections	U-10, U-20	D-28681	
Cell	Column Assemblies	U-10, U-20	D-28682	
Cell	Miscellaneous Process Pots	U-11, -17, -25	D-28687	1
Cell	Off-Gas Header and Miscellaneous Waste Receiver	VOG, U-16	E-28690	1
Cell	HCW and CD Headers	HCW, CD	E-28689	
Cell	Heat Exchangers	U-18, U-31	D-28688	
Cell and Roof	Special Equipment Details	Pulse Restrictors - Funnels V35 Assembly - 1/2 x 1/8 T Reducer	D-28710	1
Roof	Metering Head Pots	M-55, -59, -61	E-28691	
Roof and Make-up	Sight Glasses	SC-U11, -M50, -M51, -M53, and -M55	E-28692	

TABLE A-2 (Continued)

Equipment Design

<u>Area</u>	<u>Title</u>	<u>Symbol</u>	<u>Dwg. No.</u>	<u>Latest Revision</u>
Make-up	Hold Vessel for Recovered III-AX	M-53	E-28694	
Make-up	Make-up and Hold Vessel for III-AS	M-58	E-28695	
Make-up	Make-up and Hold Vessel for III-CX	M-60	E-28696	
Make-up	Make-up and Contactor Vessel for III-AX	M-50	E-28693	
Sample	Sampling Vacuum Receivers	U-40, -41, -42, -43	E-28697	
Sample	Sampling Needle Block Support Bar and Details		E-28698	
Sample	Detail of Needles		D-15754	

Layout and Structural Design

<u>Area</u>	<u>Title</u>	<u>Dwg. No.</u>	<u>Latest Revision</u>
Cell	Drainage and Concrete Floor Details	E-23499	
Cell	Floor and Wall Lining Details	E-28675	
Cell	Layout and Support of U-16, H2W, and CD	E-28689	
Cell	Equipment Layout and Support Details	E-28700	2
Cell	Wall Equipment Support Details	D-28701	
Cell	Structural for Shielding and Platforms - Plan and Elevation	D-29563	
Cell	Structural for Shielding and Platforms - Platform Plans and Details	D-29564	
Cell	Structural for Shielding and Platforms - Ladder Elevations and Details	D-29565	
Cell	Structural for Shielding and Platforms - Opening Closure and Details	D-29566	
Roof	General Area Equipment Layout and Structural	D-28702	
Roof	Decontamination Pad and Superstructure Details	D-28703	
Roof	Decontamination Panel Layout and Cutouts	D-28704	
Roof	Sleeve Cover Plates	D-28705	1
Make-up	General Area Equipment Layout and Structural	E-28706	
Make-up	Equipment Support and Structural Details	E-28707	
Sample	Sampling Needle Block Support Bar and Frame Assembly and Details	E-28698	
Sample	Glove Box Sample Station Assembly and Details	E-28699	

Piping Design

<u>Area</u>	<u>Title</u>	<u>Dwg. No.</u>	<u>Latest Revision</u>
Roof	Over-all Plan	E-28708	
Roof	Special Section and Details	E-28709	

Electrical Design (not issued to date)Sketches (to be replaced by drawings)

<u>Area</u>	<u>Title</u>	<u>Dwg. No.</u>	<u>Latest Revision</u>
Roof	Layout of New Holes	L and S	SK-III-1
Make-up	Layout of New Holes	L and S	SK-III-2
Make-up	Piping - Over-all Plan	P	SK-III-4
Make-up	Piping - Elevation Looking South	P	SK-III-5
Make-up	Piping - Elevation Looking North	P	SK-III-6
Make-up	Piping - Plan of the Tie-ins West of Area	P	SK-III-7
Sample	Layout of New Holes	L and S	SK-III-3

Main Control Board

<u>Title</u>	<u>Dwg. No.</u>	<u>Latest Revision</u>
Front Panel Layout	Q-1831-1	1
Cutouts - Indicating and Recording Panels	Q-1831-2	1
Cutouts - FR-U24 and Conoflow Panels	Q-1831-3	0
Cutouts - Motor Starter and Toggle Panels	Q-1831-4	0
Cutouts - Annunciator Panels	Q-1831-5	1
Rear View - Equipment Layout	Q-1831-8	1
Rear View - Piping Diagram	Q-1831-9	1
Rear View - Wiring Diagram	Q-1831-10	1
Terminal Strip Layout in Electrical Duct	Q-1831-12	1

TABLE A-2 (Continued)

Transmitter Rack

<u>Title</u>	<u>Dwg. No.</u>	<u>Latest Revision</u>
Front Panel Layout	Q-1831-7	1
Rear View Piping Diagram	Q-1831-13	0
Standard Panel Cutout	Q-1798-1	3
High Range Transmitter (Two Rotameters) - Frontal Piping	Q-1798-5A	1
High Range Transmitter (Two Rotameters) - Rear Piping	Q-1798-5B	0
High Range Transmitter - Typical Support Bracket	Q-1798-5C	
High Range Transmitter (One Rotameter) - Frontal Piping	Q-1798-9A	1
High Range Transmitter (One Rotameter) - Rear Piping	Q-1798-9B	0
High Range Transmitter - Bill of Materials	Q-1798-9C	0
Low Range Transmitter (Two Rotameters) - Frontal Piping	Q-1798-2A	0
Low Range Transmitter (Two Rotameters) - Rear Piping	Q-1798-2B	1
Low Range Transmitter - Bill of Materials	Q-1798-2C	0
Low Range Transmitter (One Rotameter) - Frontal Piping	Q-1798-7A	0
Low Range Transmitter (One Rotameter) - Rear Piping	Q-1798-7B	1
Low Range Transmitter (No Rotameters) - Frontal Piping	Q-1798-8A	0
Low Range Transmitter (No Rotameters) - Rear Piping	Q-1798-8B	1

Make-up Area Panel Board

<u>Title</u>	<u>Dwg. No.</u>	<u>Latest Revision</u>
Front View Layout and Cutouts	Q-1831-6	1
Rear View Piping	Q-1831-11	1

STAINLESS STEEL PISTON PULSE GENERATOR

This type of pulse generator contains a piston which is reciprocated by a variable speed electric drive unit acting through reduction gears and a drive assembly arrangement as shown in Figure A-1.

For convenience, the pulse generator is considered as consisting of three major subassemblies: the piston and cylinder, the drive assembly, and the variable speed electric drive unit.

Piston and Cylinder Assembly

The piston, which pulses the liquid, is constructed of stainless steel and is machined to a diameter that will provide clearance in the cylinder. Two Graphitar No. 41 rider rings are provided to guide the piston during reciprocation. For a piston 6 in. in diameter each rider ring consists of three segments which are $3/4$ in. thick. The rider ring segments are butted together, clamped to the piston, and machined for close clearance with the cylinder bore.

Four expanding Graphitar No. 41 piston rings seal against fluid leakage past the piston. For each ring, three equal segments are fitted together by step lap joints to form a circle. Ring expanders are installed behind each piston ring to force the ring segments against the cylinder wall. The piston ring expander is a compression spring and is made of stainless steel. The stainless steel piston rod extends upward through the piston as a connection to the drive assembly.

The cylinder is a stainless steel welded assembly bored and honed to the proper diameter and finish. The upper and lower flanges mate with the cylinder support and the flange to the pulse transmission line, respectively. A flanged nozzle welded to the cylinder barrel permits leakage from the pistons to overflow to the appropriate process vessels. A piston rod guide bushing is centered in the top flange to restrict vapor leakage.

Drive Assembly

The drive assembly converts the rotary motion from the electric motor to reciprocating motion which then transmits the reciprocation to the piston. The principal components of this assembly are an eccentric and stroke adjustment assembly for varying the stroke length of the piston from 0 to 2.5 in.

Varidrive Electric Motor

The electric motor used to drive the pulse generator produces a variable output speed ranging from 30 to 120 rpm.

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Fig. A-1
PISTON PULSE GENERATOR

KS-17485
UNCLASSIFIED

Performance of Piston Pulse Generators

The performance of four stainless steel piston pulse generators (6 in. diam) has been satisfactory. The generators have been in operation for approximately five years and have pulsed columns varying in size from 6 to 10 in. in diameter. The leakage of fluid past the piston gradually increases with wear, and it has been necessary to replace the seal rings in each piston after about each year of operation. Seal rings are replaced when the fluid leakage exceeds 5 gph. It has not been necessary to replace any of the stainless steel cylinders. This type of pulse generator is recommended for use in a radiochemical separations plant if the unit is located remotely from the pulse column and in a limited access area of the plant where minor maintenance and repair may be performed. Pulse generator units of this type with a piston diameter up to 30 in. have operated successfully.

PISTON-DIAPHRAGM PULSE GENERATOR

During the last five years Lapp Pulsafeeder pumps have been used extensively as pulse generators in radiochemical processing plants. The Pulsafeeder pump is a combination piston-diaphragm pump (Figure A-2) and is converted to a pulse generator by removing the check valve assembly. An exclusive and unique method of eliminating the necessity of a packing gland and stuffing box is adopted in the form of a hydraulically balanced diaphragm. The reciprocation of the piston in the cylinder hydraulically moves liquid against the diaphragm to impart perfect balance and allow the diaphragm to follow the reciprocating motion of the piston. Automatic compensator valves are connected to the compression head; the function of the valves is to provide an exact volume of liquid between the piston and diaphragm. All leakage is compensated for, and the excess pressure is automatically dissipated. The reciprocation of the piston causes the diaphragm to move forward and backward, and when the opposite side of the diaphragm is connected to a pulse column, a pulsing motion is transmitted to the column. All Pulsafeeders are furnished with a piston stroke adjustment.

Reagent heads are constructed of stainless steel, and diaphragms of stainless steel, Teflon, and Kel F have been used.

The Pulsafeeder pulse generators are driven by a varidrive electric motor, and pulse frequencies can be varied from 30 to 84 strokes per min.

Performance and Advantages of Piston-Diaphragm Pulse Generator

The performance of the Lapp Pulsafeeder pulse generators has been very satisfactory. Two units have been operated for 4 years without any trouble, which indicates that a long service life may be expected.

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Fig. A-2
LAPP PULSAFEEDER PULSE GENERATOR

KAPL-1808

KS-17486
 UNCLASSIFIED

Some advantages that piston-diaphragm pulse generators have over the piston pulse generators are:

1. The leakage past the piston is eliminated by the use of a diaphragm.
2. Reagent head of piston-diaphragm generator may be located remotely from the hydraulic drive unit.
3. Increasing the static pressure on the diaphragm does not affect leakage rate.
4. Better control of process solution flow rates to columns is possible.

Limitations of Piston-Diaphragm Pulse Generator

The capacity of piston-diaphragm pumps, which are commercially available at the present time, limits the use of these pumps to pulse columns having a diameter of approximately 8 in. or less. For pulse columns with diameters greater than 8 in. the stainless steel piston pulse generator is cheaper and requires less space.

INTERFACE CONTROLLERS

All columns require:

- 1 - Taylor Fulscope controller
- 1 - Taylor differential pressure transmitter, model 206 RF
- 1 - Bubbler

Air supply with filter.

Vendor: Taylor Instrument Companies
Olsen and Ames Street
Rochester 1, New York

INTERFACE CONTROL VALVES

All columns require:

- 1 - Research Controls' diaphragm valve, model 75-SM, 1/8-in. outlet and inlet, Type 316 stainless steel body and trim, air to open action.

Vendor: Research Controls
P.O. Box 5035
Tulsa, Oklahoma

"MINI" MIXER-SETTLER DRAWING INDEX (Latest KAPL Design)

1. Design by: Knolls Atomic Power Laboratory
General Electric Company
Schenectady 1, New York

Contact: Mr. R. S. Miller

2. Fabricator: Westlake Manufacturing Company
Charles Street
Canastota, New York

Contact: Mr. A. T. Sheppard

3. Drawing index

General Electric Company Drawing Nos.:

K-6A5310	K-6A5323
K-6A5311	M-6A6454
K-6A5312	P-6A8778
K-6A5313	P-8A7101
K-6A5314	P-8A7102
K-6A5319	M-8A4003
K-6A5320	604C235

4. Zenith pump feed system for "Mini" mixer-settler

Reference: J. W. Coddling, H. W. Alter, "A Recent Model of the Miniature Mixer-Settler," AECD-3733, December 15, 1954.

Vendor: Zenith Products
58 Chestnut Street
West Newton 56, Massachusetts

5. Reduction gears for Zenith pump feed system

Reference: J. W. Coddling, H. W. Alter, "A Recent Model of the Miniature Mixer-Settler," AECD-3733, December 15, 1954.

Vendor: Boston Gear Works, Inc.
3200 Main Street
Quincy, Massachusetts

6. "Mini" mixer-settler drive motor.

Bodine Electric Company
 1725 rpm dc continuous duty motor
 1/15 hp 0.75 amp
 Type NSH-34

Vendor: Bodine Electric Company
 2272 West Ohio Street
 Chicago, Illinois

7. Variac control for mixer-settler drive motor.

General Radio Company
 Type No. 1701-AK
 Field 0.2-amp fuse
 Armature 0.8-amp fuse

Vendor: General Radio Company
 275 Massachusetts Avenue
 Cambridge 39, Massachusetts

"MIDI" MIXER-SETTLER (Latest KAPL Design)

1. Design by: Knolls Atomic Power Laboratory
 General Electric Company
 Schenectady 1, New York

Contact: Mr. R. S. Miller

2. Fabricator: Any competent job shop

3. Drawing Index: T-7A9484 P-7A7078
 P-7A4076 P-7A7079
 P-7A7077 M-7A3252

4. Impellers for "Midi" mixer-settler

Reference: KAPL Print No. M-7A3252

Vendor: General Electric Company
 Development Foundry
 1 River Road
 Schenectady, New York
 Attn: Mr. S. A. Eliot, Building 59

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MIXER-SETTLERS

General

7. Coplan, B. V. and Davidson, J. K., "A Review of Contacting Equipment for Continuous Countercurrent Solvent Extraction Processes," TID-2008, 89-102 (March 1953).
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Pump-Mix Mixer-Settlers

Pilot-Scale

9. Coplan, B. V., Davidson, J. K., Holmes, J. H., and Schafer, A. C., Jr., "The Multi-Stage Pump-Mix Mixer-Settler," KAPL-513, April 21, 1951.
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