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Recovery of Uranium from Phosphoric Acid*

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Recovery of Uranium from Phosphoric Acid

SLIDE

During the production of phosphate fertilizer material the raw phosphate rock or apatite which contains uranium is treated with sulfuric acid to produce an intermediate product called wet-process phosphoric acid or 30% P_2O_5 acid and waste product, gypsum. About 5 tons of gypsum is produced for each ton of P_2O_5 and this greyish white material is stored in large piles next tc the phosphoric acid plant while the wet-process phosphoric acid is evaporated to a more concentrated form for conversion to fertilizer.

SLIDE

The uranium is recovered from the phosphoric acid by either a single cycle or two cycle so-called solvent extraction technique. This is a process in which the uranium is selectively extracted into an organic solution and then stripped back into a second water-containing stream and is concentrated later. Usually there are included pretreatment and posttreatment steps along with the first cycle solvent extraction circuit.

There are at least three solvent extraction processes available for recovering the uranium; (1) the pyro process in which a long chain alcohol (e.g. capryl alcohol) is reacted with phosphorous pentoxide (P_2O_5) on site to prepare the extractant, (2) the DEPA-TOPO process which uses a mixture of di-2ethylhexyl phosphoric acid (DEPA) and trioctylphosphine oxide (TOPO) and (3) the OPAP process which uses octylphenyl acid phosphate as the extractant. All of these materials are dissolved in a kerosene type diluent or extender. You might look for drums with the names, capryl, D2EHPA, TOPO or OPAP printed on them.

SLIDE

This slide shows a typical flowsheet of the two cycle process and consists of pretreatment to clean up the acid, first and second cycle solvent extraction circuits and uranium refining. The uranium laden phosphoric acid is pumped into a large clarifier unit to remove solids and then through towers of activated carbon to remove organic matter. Depending on the process used, the acid may be treated with hydrogen peroxide (H_2O_2) to oxidize the uranium or passed through a bath of scrap iron or iron filings to reduce the uranium. Here you might look for drums labeled H_2O_2 or see iron scrap laying around. In most cases the solution will also be pumped through a couple of heat exchangers to cool the acid. After cleaning and cooling, the acid is pumped into a series of 4 to 5 mixer-settler units countercurrent to a stream of solvent which extracts the uranium from the acid. Uranium is then stripped from the solvent in another 3 to 4 mixer-settler units. This step concentrates the uranium by a factor of 50-100 and this aqueous strip solution is pumped to the second cycle. The solvent goes round and round in the first cycle circuit as it is cycled between extraction and stripping units. The main phosphoric acid stream (or raffinate), after removal of the uranium, is pumped to a large hold-up tank and then through an air flotation unit to remove entrained solvent before returning the acid to the acid plant for evaporation. The strip solution is then pumped to an oxidation tank for oxidation of the uranium. There may be a tank of H_2O_2 in the vicinity. The oxidized solution is pumped to the second cycle for further treatment or may be pumped to a tank truck so it can be carried to the central recovery facility.

The second cycle, when compared to the first cycle, is a very small scale operation consisting of an extraction circuit with ~3 pilot-plant size mixer-settler units, a scrub section with ~2 mixer-settler units and a carbonate strip circuit with 2 mixer-settler units. You might look for drums or tanks of ammonia and carbon dioxide. A yellow uranium product is recovered from this circuit. This material is calcined by heating to 600-800°C to remove carbon dioxide and ammonia and form uranium oxide. Special precautions will be taken in this area to prevent the spread of the radioactive powder and radiation symbols will be present.

Now, lets take a look at some of the inidividual units.

This next slide shows a mixer-settler unit, one of the key components of a solvent extraction process.

SLIDE

Each unit is considered to be a stage. These units may range from 10 ft wide by 20 ft long to 20 ft by 50 ft or larger. Usually, there will be 7 to 9 units or stages in a row. The mixers will be on alternate ends of adjoining stages. In some cases round mixers and settlers may be used.

Another important piece of equipment, a gravity thickener will probably be present. This slide shows a schematic drawing of such a unit.

SLIDE

They usually run about 100 ft in diameter and are used in pretreatment for calrification of the acid.

One other piece of equipment worth noting is the air flotation unit used in posttreatment to clean up thr acid before return to the acid plant. This is shown in the next slide.

SLIDE

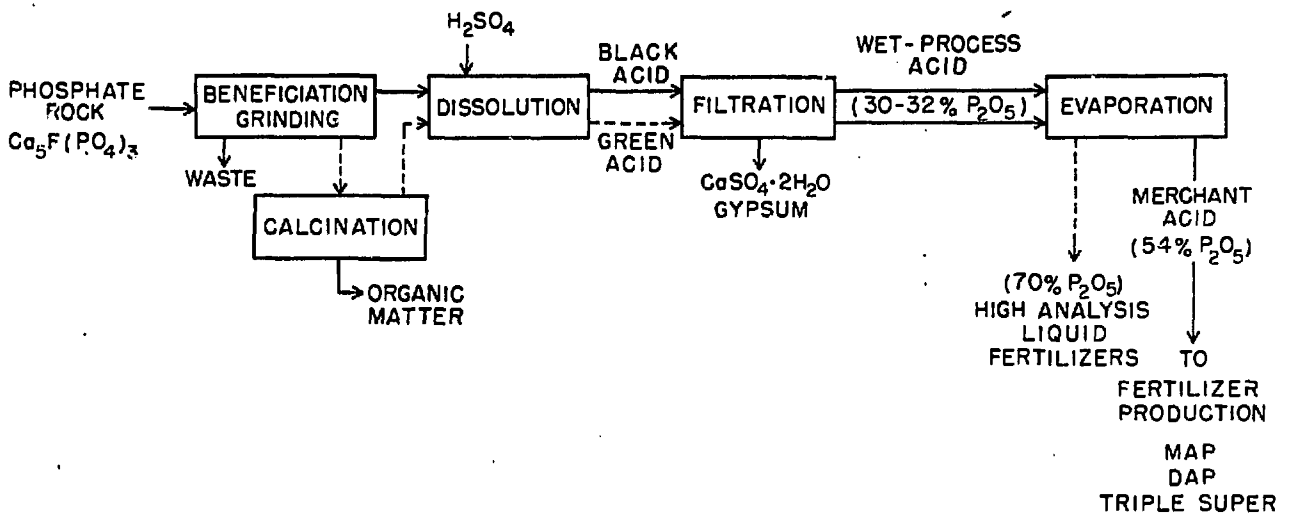
Finally, lets take a look at an actual uranium extraction facility at a phosphoric acid plant in the last slide --

SLIDE

A cluster of 10 mixer-settler units can be seen in the foreground. Unfortunately, the other units are lost in the background.

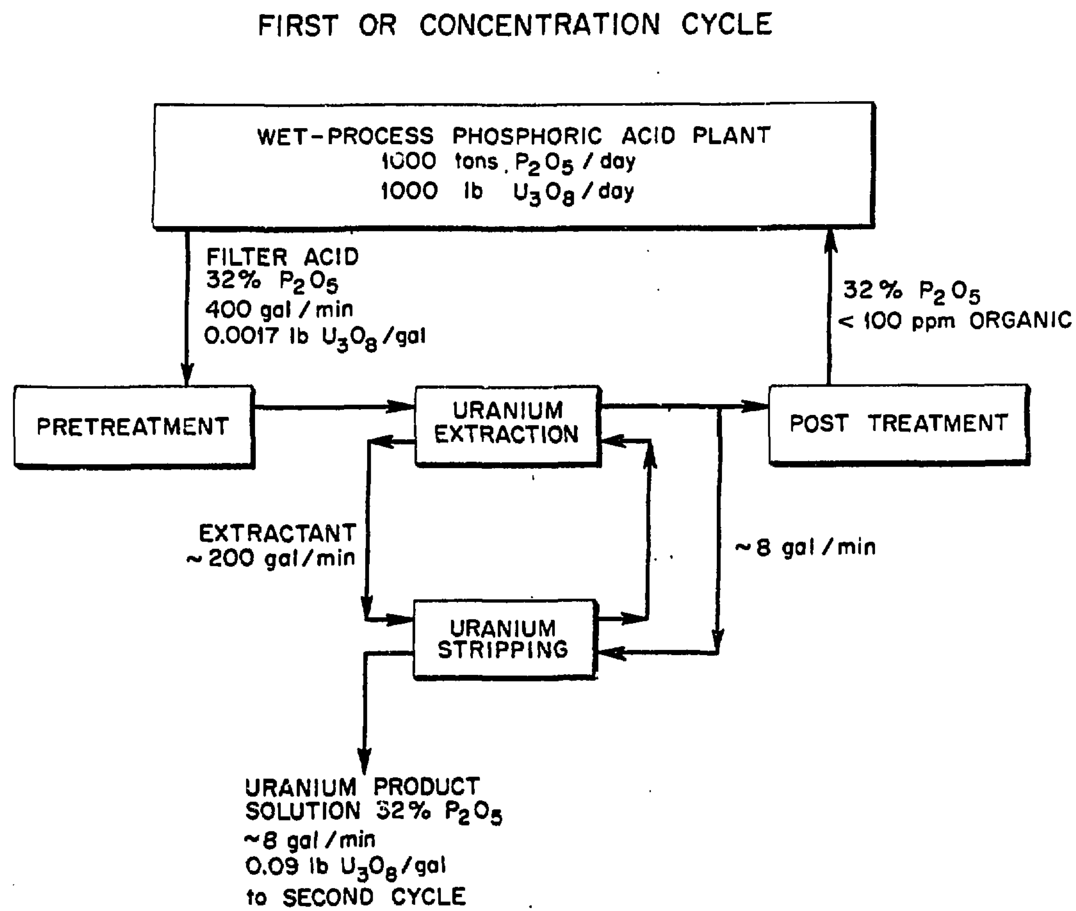
In conclusion, because of miscellaneous tanks, miles of piping, etc. it may be very difficult to pick out a uranium recovery facility. Mixer-settlers will probably be the easiest equipment to spot. Secondly, chemical names and symbols may give a clue. For this reason the next slide shows a list of the major chemicals that may be expected.

SLIDE



SIMPLIFIED FLOWSHEET FOR WET-PROCESS H_3PO_4 PRODUCTION

ORNL DWG 76-14733



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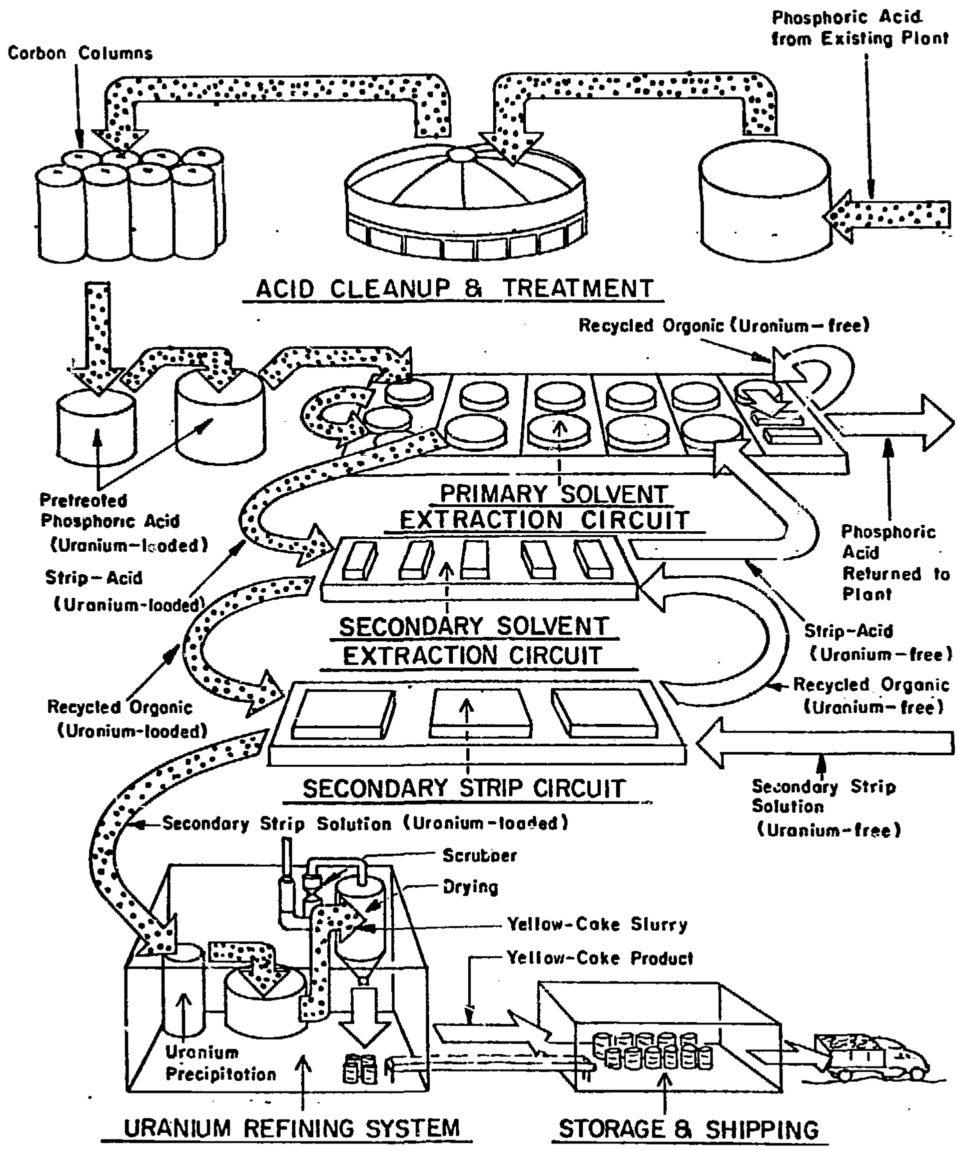
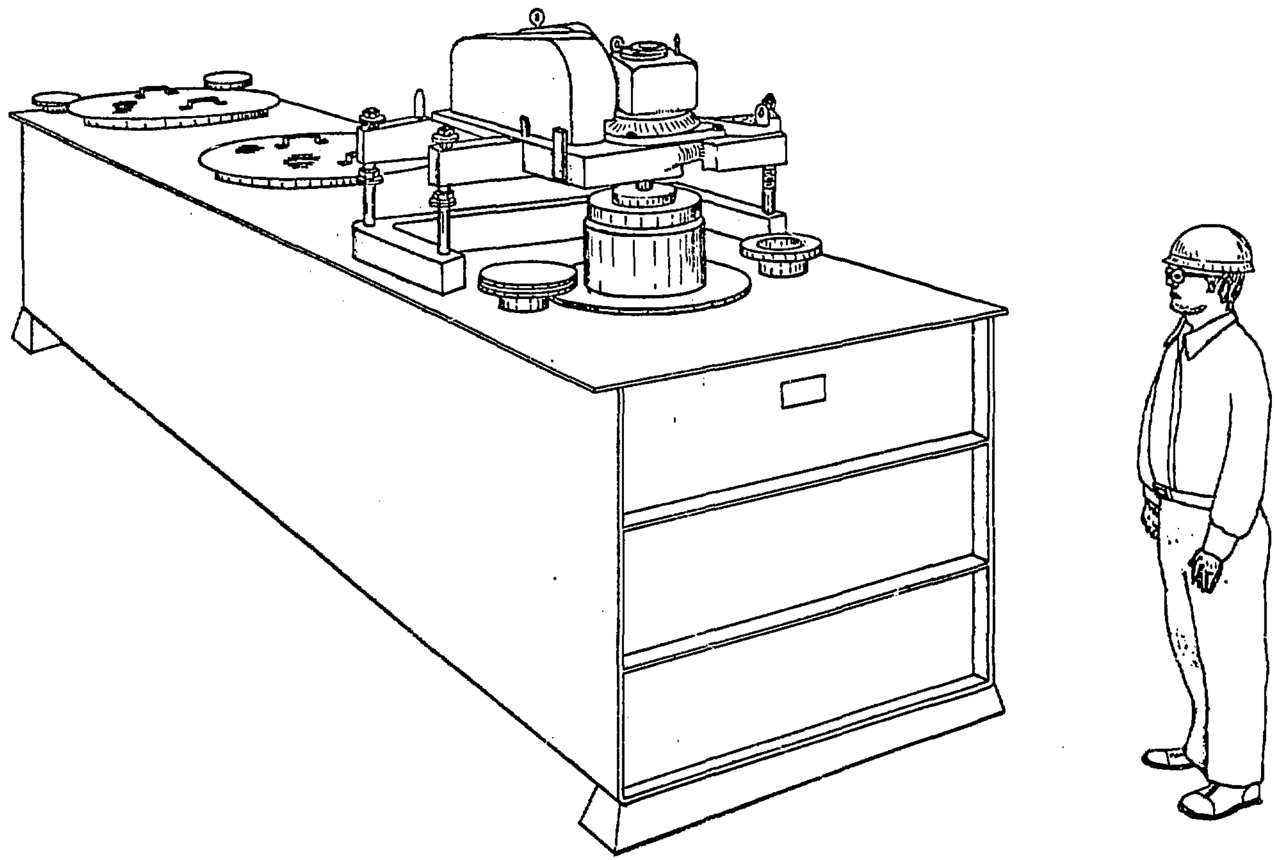
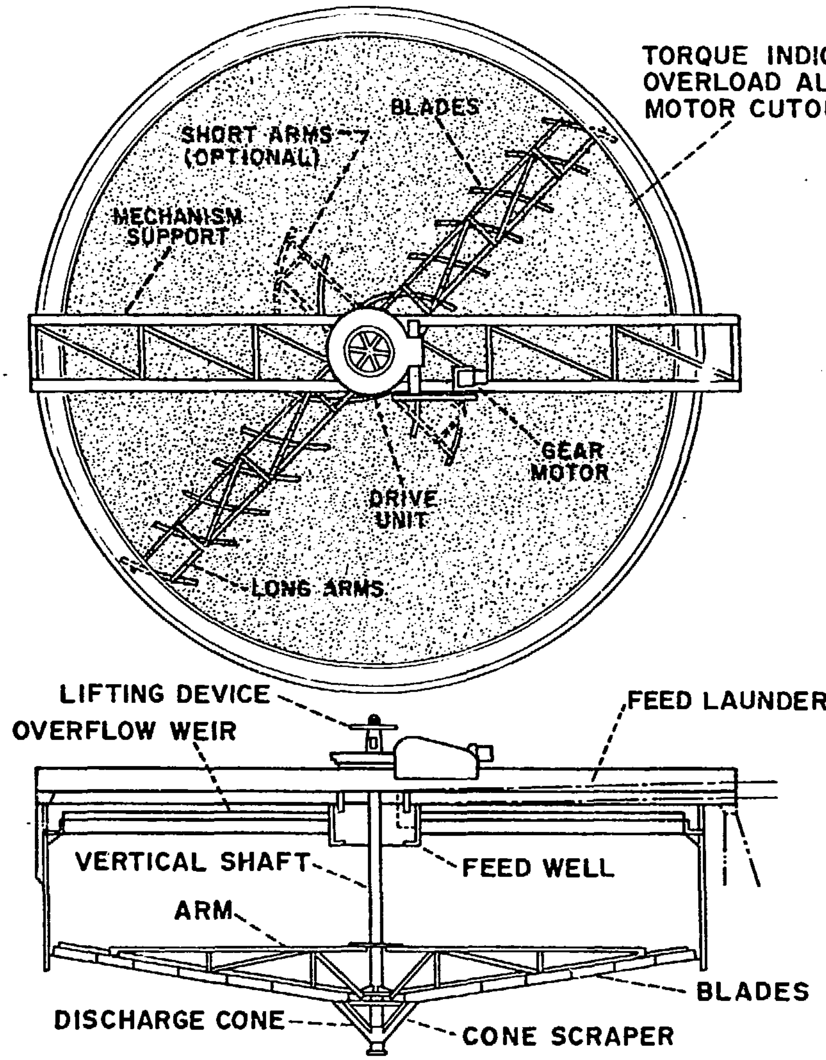


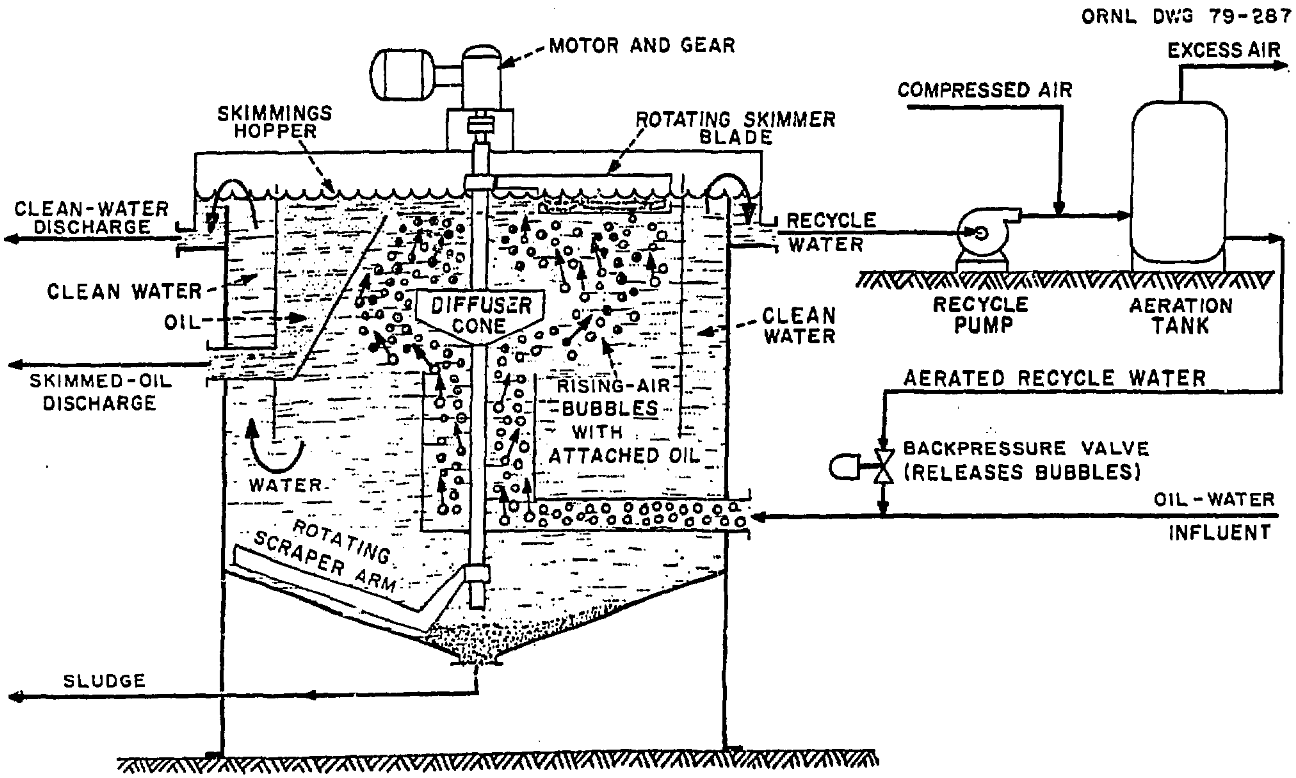
URANIUM RECOVERY PROCESS

ORNL DWG 79-208

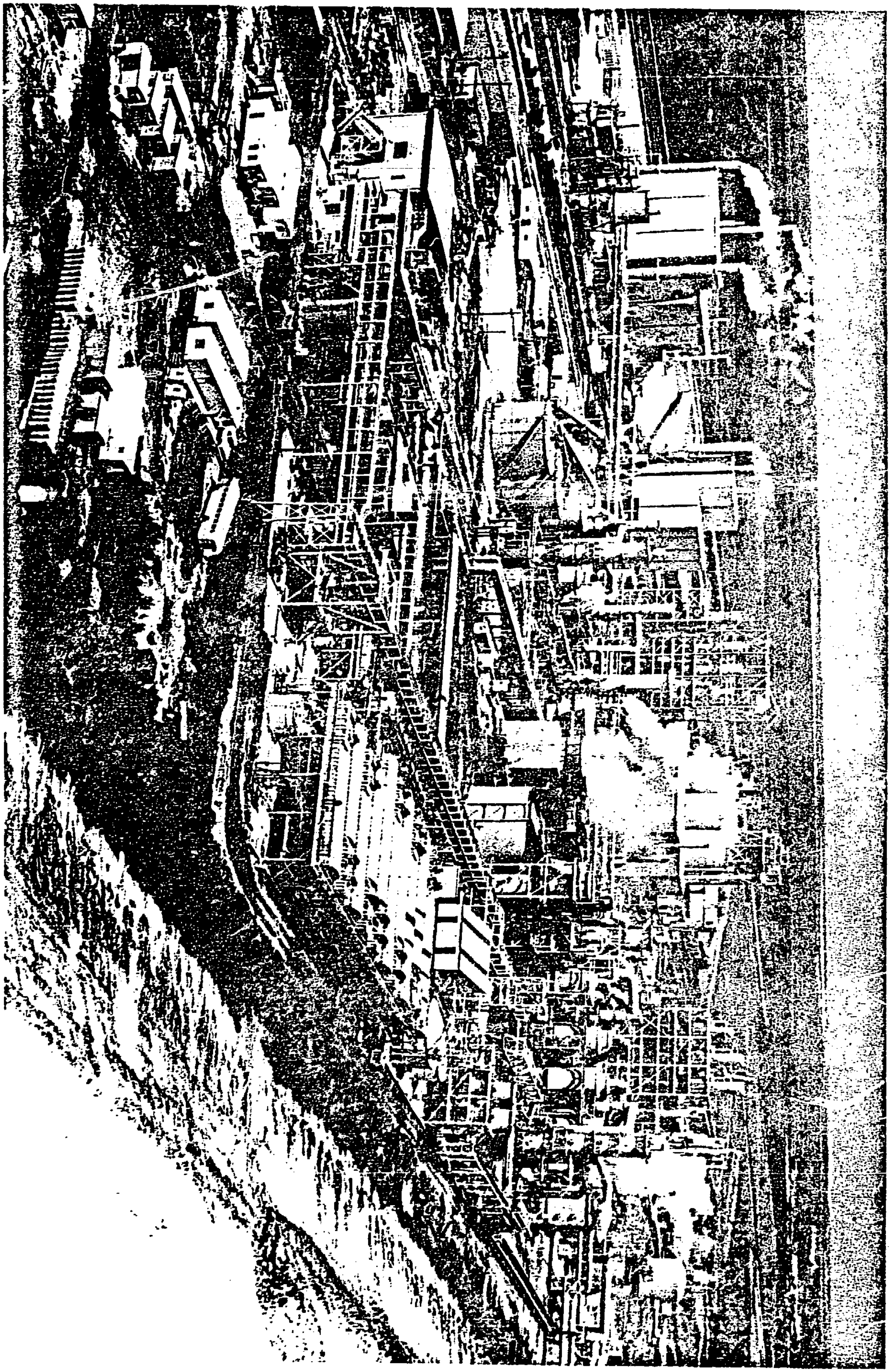


ORNL DWG 79-288





ORNL DWG 79-287
MOTOR AND GEAR
EXCESS AIR
COMPRESSED AIR
SKIMMINGS HOPPER
ROTATING SKIMMER BLADE
CLEAN-WATER DISCHARGE
RECYCLE WATER
CLEAN WATER
OIL
DIFFUSER CONE
CLEAN WATER
RECYCLE PUMP
AERATION TANK
SKIMMED-OIL DISCHARGE
RISING-AIR BUBBLES WITH ATTACHED OIL
AERATED RECYCLE WATER
BACKPRESSURE VALVE (RELEASES BUBBLES)
WATER
OIL-WATER INFLUENT
ROTATING SCRAPER ARM
SLUDGE



Chemicals Used in the Process

Chemical	Symbol
Phosphoric acid	H_3PO_4, P_2O_5
Sulfuric acid	H_2SO_4
Gypsum	$CaSO_4 \cdot 2H_2O$
Uranium	U, U_3O_8, yellow cake
Iron	Fe
Hydrogen peroxide	H_2O_2
Ammonia	NH_3
Carbon dioxide	CO_2
Di-2ethylhexyl phosphoric acid	D2EHPA
Trioctylphosphine oxide	TOPO